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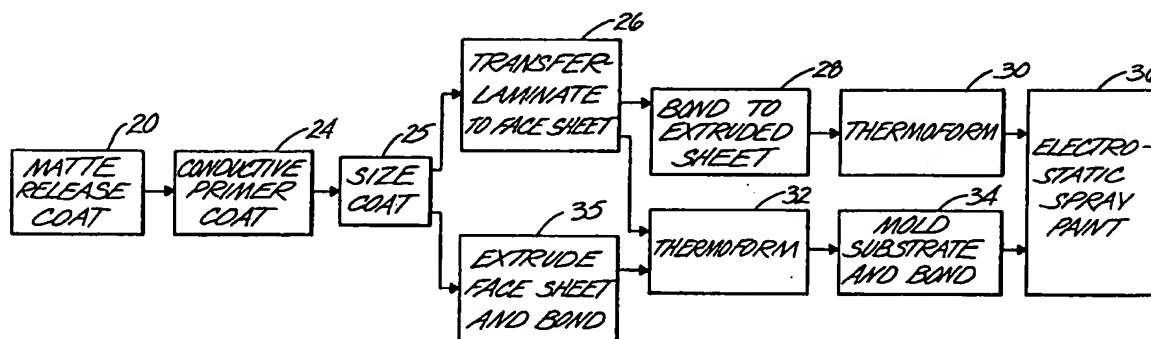
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(71) Applicant: AVERY DENNISON CORPORATION [US/US]; 150 North Orange Grove Boulevard, Pasadena, CA 91103 (US).			
(72) Inventors: ENLOW, Howard, H. ; 1334 Camelia Drive, Munster, IN 46321 (US). HUFFER, Scott, W. ; 133 N. Ridge Street, Crown Point, IN 46307 (US). YOUNG, Fredrick ; 152 Holly Lane, Schererville, IN 46375 (US). BUEHNE, William, J. ; 7325 McCook Avenue, Hammond, IN 46323 (US).			
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(54) Title: THERMOFORMABLE CONDUCTIVE LAMINATE AND PROCESS



(57) Abstract

A process for making a thermoformable conductive plastic laminate for use in making plastic parts adapted for electrostatic spray painting of a uniform high quality paint finish includes forming a matte release coated casting sheet (20), casting an electrically conductive polymer (24) in thin film form on the casting sheet, drying to form a conductive primer coat (24), and transfer-laminating the conductive coating to a thin, thermoformable plastic face sheet (26). The matte release coat (20) has fine particulate filler that transfer a micro-roughened matte surface to the conductive primer coat (24). The conductive primer (24) includes a polyester resin containing a fine particulate conductive material such as carbon black and, preferably, an anti-blocking agent such as fumed silica. The primer coated face sheet (26) can be thermoformed and bonded to an underlying plastic substrate panel (28). The conductive primer (24) has sufficient elongation and maintains uniform electrical surface conductivity and film thickness throughout the transfer-laminating, thermoforming and substrate panel-cladding process. The uniform surface resistivity of the conductive primer film (24) is sufficient to permit electrostatic spray painting of the finished contoured panel and in one embodiment of the finished contoured panel and in one embodiment produces a Class "A" quality exterior automatic paint finish on the resulting panel.

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10 THERMOFORMABLE CONDUCTIVE LAMINATE AND PROCESS

Cross Reference to Related Applications

This is a continuation-in-part of application
Serial No. 07/887,535, filed May 22, 1992.

15 Field of the Invention

This invention relates to the use of a
thermoformable conductive laminate in the electrostatic
painting of plastic substrate panels.

20 Background of the Invention

One embodiment of the present invention relates
generally to the electrostatic painting of plastics.
Although the invention is described below with relation
to the electrostatic spray painting of plastic car body
25 panels, it should be understood that the invention has
further uses which will become more apparent from the
description to follow.

In a typical electrostatic spray painting process,
the spray head is maintained at a high voltage (50-140
30 KV) while the object being sprayed (the substrate) is
electrically grounded. When a metal substrate is
painted, it is relatively simple to maintain the metal
at ground potential. In the electrostatic painting
process, particles (paint droplets) are charged by an
35 electrode in the spray head, and a charged spray cloud
from the spray head is attracted to the metal surface
by the high voltage difference. This process greatly

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1 reduces over-spray and produces a high quality surface
on the painted metal parts. For these reasons, and
others, electrostatic spray painting techniques have
been used for many years in the automotive industry for
5 spray painting exterior body panels made of sheet
metal.

In recent years, the automotive industry has
increased its use of plastic materials for exterior car
body panels and trim parts. The predominant reasons
10 are weight-reduction and the fact that car builders
have had available more sophisticated high impact
strength plastics such as polycarbonates. To a large
extent, the future success of plastics for large car
body panels will depend on their ability to be painted
15 "on-line" in the assembly plant with a class "A"
quality appearance similar to painted metal car body
panels. Electrostatic spray painting of plastic car
body panels has been used for years. However,
difficulties arise when using electrostatic spray
20 techniques for painting plastic substrates. The
problem is particularly difficult when the objective is
to paint plastics with the same high quality and
appearance as metal parts using electrostatic paint
spray equipment.

25 In order to electrostatically spray paint plastic
substrates, a number of technical problems must be
overcome. For instance, electrostatic charges
accumulate on the surface of a plastic substrate during
the electrostatic spray painting process. The charges
30 that accumulate do not dissipate as readily as with
metals. This accumulation of charges reduces the
potential between the spray head and the substrate,
leading to weaker electrical forces on the charged
paint droplets. The accumulated charges on the
35 substrate surface also cause an opposing electrical
field that repels air-borne paint particles; and the
accumulated charges tend to produce a non-uniform field

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1 across the surface. These phenomena produce a self-limiting effect of yielding less paint deposition and producing less uniformity in the build-up of the paint film when compared with painting metal substrates.

5 In addition, some plastics have retained charges that may continue to exist for long time periods after the paint has been sprayed, making the painted surface more vulnerable to dust attraction.

10 As a result of these problems, it has been difficult to achieve a high quality Class "A" paint coat by electrostatic painting of plastics. The problem is particularly difficult when the objective is to apply uniform paint coats to plastic panels having complex three-dimensional shapes.

15 One solution to the problem has been to search for certain plastic substrate materials that will alleviate the surface charge problem and the resulting low deposition and non-uniform build-up of paint films on plastics. This approach has not proved successful to date.

20 Another approach has been to develop electrically conductive primers which are air-sprayed onto the plastic substrate prior to electrostatically spraying on the finished paint film. Use of a conductive primer can reduce the problems of accumulated electrostatic charges, low paint film build-up and non-uniform conductivity and film thickness. A further approach has been to add conductive materials to the molding compound, but this can degrade the physical properties of the finished part. Use of conductive polymers has also been tried, but this approach is too expensive.

30 In order to use such conductive primers, certain technical problems first must be overcome. There is a need for good adhesion of the primer to the plastic substrate. Special problems have been controlling the surface smoothness of the primer and achieving good adhesion to low energy substrates such as TPO

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1 (thermoplastic polyolefin) and polypropylene. The
conductive primer also should have a good level of
surface conductivity along with humidity insensitivity,
uniformity of conductivity across the primer surface,
5 and durability. If surface conductivity is too low,
non-uniform build-up of the paint film can result.
Surface conductivity, as measured in terms of
"resistivity" (ohms per inch or ohms per square),
should be reasonably insensitive to humidity; otherwise
10 non-uniformities in conductivity and in the paint film
build-up are produced. Other factors also can alter
the uniformity of surface conductivity. When coating
thickness varies as the primer is applied, it is also
more difficult to achieve such uniformity.

15 Generally speaking, the use of conductive primers
for plastic substrate panels in the automotive industry
has not been successful in economically producing a
Class "A" quality finish. Because of non-uniform
conductivity and primer film thickness, these priming
20 techniques have resulted in a generally poor appearance
of the finished paint film. That is, a non-uniform
primer, even though an undercoat in the process, can
create a poor appearance of the finished exterior paint
coat. It is difficult to produce a uniform paint film
25 thickness with a primer applied by non-electrostatic
air spray techniques, followed by air spraying a
charged-particle paint film. Moreover, even with
uniform conductivity and primer thickness, the sprayed
surface can result in less than a Class "A" finish,
30 such as an "orange peel" surface. In addition, the
techniques of using conductive primers have resulted in
a high scrap rate and increased production time. The
current method of priming plastic parts for
electrostatic paint spraying is by adding an additional
35 step by either shipping to a separate location for
priming, or priming on the paint line at the assembly
plant. This amounts to high transportation and

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1 handling costs and a higher than normal scrap return
rate. It also creates an additional source of volatile
organic compounds. If the full car body is
5 successfully made of plastic, the current use of a
plating bath for metal parts can be eliminated from the
production process.

The present invention, in one embodiment, provides
a thermoformable conductive laminate that converts a
non-conductive surface to a conductive surface for
10 electrostatic painting applications. The conductive
laminate overcomes the problems of non-uniform
conductivity and film thickness, as well as providing
a high level of conductivity uniformly across the
surface of the laminate. The laminate is formed by
15 techniques that provide a uniform conductive primer on
the surface of the thermoformable laminate. The
resulting laminate can be thermoformed into complex
three-dimensional shapes which can then be
electrostatically sprayed with a uniform paint coat
20 after thermoforming. When used as a component in a
plastic car body panel, the thermoformed laminate can
be bonded to a substrate, for example, molded with
thermoplastic resins, or molded with thermoset resins
by various sheet molding techniques, or vacuum pressure
25 formed and bonded to the plastic substrate. Examples
of molding techniques and materials include SMC (sheet
molding compound), BMC (bulk molding compound), TMC
(thick molding compound), RIM (reaction injection
molding), and RTM (resin transfer molding). (TMC is a
30 trademark of Takela Chemical Industries, Ltd.) The
primed part is then ready for painting directly after
molding with thermoplastics or thermosets, or vacuum
pressure forming. This eliminates the extra
transportation and cycle time costs associated with the
35 current off-line process of electrostatically spray
painting plastic car body panels. As a further
advantage, the conductive primer retains uniformity of

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1 its conductivity throughout the thermoforming process.
The primer comprises an electrically conductive uniform
film with good elongation and adhesion properties. By
maintaining its uniform conductivity during
5 thermoforming, a paint coat applied to the primed
conductive surface can achieve a Class "A" quality
finish, even for complexly shaped panels. Less over-
spray and scrap rate also are produced.

In addition to its use in the automotive industry,
10 the invention can be used for making any contoured
plastic panel in preparation for electrostatic spray
painting. The thermoformable conductive laminate can
be used for making doors or cabinets, or used in the
electronics industry, for example, in electromagnetic
15 shielding.

Summary of the Invention

Briefly, one embodiment of this invention
comprises a process for making a thermoformable
20 conductive plastic laminate that can be used to make
plastic parts adapted for electrostatic spraying or
electromagnetic shielding to produce a uniform painted
finish. The process includes forming a temporary
flexible casting sheet, preferably release coated, more
25 preferably matte release coated, followed by casting
onto the casting sheet an electrically conductive
polymeric material in thin liquid film form of uniform
film thickness. The electrically conductive polymeric
material or primer, in one embodiment, includes a
30 polyester resin containing a fine particulate
conductive material, such as carbon black, and an anti-
blocking agent, such as a dispersion of fumed silica.
The components of the formulation are controlled so
that upon drying to a uniform film thickness by solvent
35 evaporation, the surface resistivity (or conductivity)
of the conductive primer film is electrostatically
sprayable. A conductive primer coat which is

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1 electrostatically sprayable is in an optimal range of
about 110 units or more on the Ransberg scale, or from
about 5 to about 50 K-ohms/inch. The conductive primer
5 has inherent adhesion qualities to adhere to a plastic
face sheet, and under thermolaminating techniques the
primer is transferred from the casting sheet to a thin,
semi-flexible, thermoformable plastic face sheet by dry
paint transfer laminating techniques. The resulting
10 laminate then can be thermoformed into a complex three-
dimensional shape, such as the shape of a car body
panel. The carbon black and fumed silica contained in
the primer accelerate the solvent release and produce
a smooth coating that can produce a Class "A" quality
15 exterior automotive paint finish when subsequently
painted by electrostatic spray painting techniques.
The preformed laminate can be bonded to an underlying
plastic substrate material by injection cladding or
thermoset molding techniques, for example, to form the
finished article. The conductive primer coat has
20 sufficient elongation and is able to maintain
uniformity of conductivity throughout the thermoforming
process so that the high quality finished paint coat
can be produced on the outer surface of the resulting
substrate. The electrical surface resistivity is
25 retained within its desired range throughout the
transfer-laminating step and the thermoforming step.

As a further advantage, the invention is useful in
the electrostatic spray-painting of high temperature-
resistant plastic substrate panels. These panels are
30 commonly made by the so-called engineering plastics
using thermoset molding techniques. In some instances
electrostatic spray painting of these plastics in the
past has experienced adhesion problems; however, the
conductive primer of this invention provides good
35 adhesion, as well as good surface conductivity, for
these substrate panels.

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1 These and other aspects of the invention will be
more fully understood by referring to the following
detailed description and the accompanying drawings.

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1 Brief Description of the Drawings

5 FIG. 1 is a block diagram illustrating steps in a process for making panels from a thermoformable conductive laminate according to principles of this invention.

10 FIG. 2 is a schematic cross-sectional view illustrating one embodiment of a matte release coated carrier and conductive primer coated laminate used in a process for making electrostatically sprayable plastic panels.

 FIG. 3 is a schematic elevation view illustrating an in-line process for applying the matte release coat and the conductive primer coat.

15 FIG. 4 is a schematic elevation view illustrating a transfer-laminating step of the process.

 FIG. 5 is a schematic view illustrating a thermoforming step of the process in which a paint coated laminate is heated prior to vacuum forming.

20 FIG. 6 is a schematic view illustrating another thermoforming step in the process.

 FIG. 7 is a schematic cross-sectional view illustrating a preliminary step in an injection-cladding step of the process.

25 FIG. 8 is a schematic cross-sectional view illustrating a substrate material injection molded behind the thermoformed laminate in an injection mold.

30 FIG. 9 is a schematic cross-sectional view illustrating a contoured plastic car body panel having an electrostatically spray painted exterior weatherable Class "A" automotive paint finish.

 FIG. 10 is a schematic side elevational view showing a process for forming a conductive composite laminate comprising a conductive coating and an extruded plastic sheet.

35 FIG. 11 is a schematic side elevational view showing a process for forming a conductive laminate

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1 comprising a conductive coating and an extruded plastic
sheet.

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1 Detailed Description

FIG. 1 is a schematic block diagram illustrating steps in a process for electrostatically spray painting plastic panels made with a thermoformable conductive laminate according to this invention. The process is described in relation to its use in making exterior automotive body panels having an electrostatic spray painted finish, although other uses of the invention are possible as will become more apparent from the description to follow.

Referring to FIG. 1, a paint coat with a surface capable of exterior automotive use is applied to a molded contoured plastic car body panel by electrostatic spray techniques. The process includes applying a release coat 20 to a carrier sheet 22, followed by drying the release coat on the carrier. The preferred release coat is a matte release coat because of its processing advantages described below; however, other release coats may be used. The process further includes applying an electrically conductive resinous coating of uniform film thickness to the release-coated carrier, and drying the conductive coating on the carrier to form a uniform conductive primer coat 24. An optional size coat 25 is applied to the primer, followed by drying the size coat. There are several options in bonding the conductive primer coat to a plastic substrate panel. In one option, the conductive primer coat is transfer-laminated to a thin, thermoformable plastic face sheet 26. The size coat 25 bonds the conductive primer to the face sheet. The carrier is stripped away in the transfer-laminating step to release the carrier and its matte release coat from the primer. The matte release coat remains bonded to the carrier that is stripped away. The thermoformable conductive laminate can be bonded to an extruded plastic substrate panel 28 and then thermoformed to a finished substrate in a subsequent

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1 thermoforming step 30; or the conductive laminate can
be thermoformed in a thermoforming step 32 to form a
thin, contoured, conductive face sheet, followed by
bonding the conductive face sheet to a molded plastic
5 substrate panel 34. The substrate panel can be formed
by thermoset or thermoplastic molding, or vacuum
pressure forming techniques. FIG. 2 illustrates an
extruded tri-layer substrate panel having mutually
bonded extruded layers 28a, 28b and 28c described in
10 more detail below. An optional size coat 27 can be
coated on the face sheet 26 to improve bonding to the
substrate. Referring again to FIG. 1, the conductive
primer also can be laminated directly to an extruded
face sheet, in an extrusion laminating step 35. In
15 this option, the conductive face sheet then can be
thermoformed 32 and bonded to a molded substrate 34.
The conductive primed laminate can be shaped into the
desired highly contoured finished shape while
maintaining a high level of conductivity sufficient for
20 subsequent electrostatic spray coating of an exterior
automotive paint film 36. The finished paint coat can
be a weatherable, durable glossy exterior automotive
paint. These include the more rigid highly cross-
linked thermoset enamel, urethane or acrylic lacquers,
25 as well as more flexible paint finishes of vinyl, or
fluoropolymer resins. Of the latter type are
polyvinylidene fluoride (PVDF) or PVDF-acrylic blends.
The conductive primer retains uniformity of its
conductivity throughout the thermoforming and substrate
30 molding steps and facilitates forming a Class "A"
exterior automotive finish electrostatically spray
painted on the contoured panel surface.

FIG. 2 schematically illustrates one embodiment of
the process for making the thermoformable laminate.
35 The matte release coat 20 is coated onto the surface of
a flexible, foldable, heat resistant, self-supporting
carrier sheet 22, also referred to in the art as a

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1 casting film. The carrier sheet is preferably a
polyester casting film such as Mylar (a trademark of Du
Pont), or American Hoechst 2000 PET film. The
polyester carrier film has a sufficiently high heat
5 resistance to resist axial elongation under
temperatures applied during subsequent matte release
coat and primer coat drying steps.

The matte release coat 20 comprises a
thermosetting resinous coating having a low gloss
10 matting agent dispersed in it, together with a release
agent which freely releases the release coated carrier
from coatings applied subsequently to the carrier.
Other release systems are possible at a range of gloss
levels. In one embodiment the release agent includes
15 a wax component contained in the synthetic resinous
coating for enhancing release of the matte release
layer, together with a silicone resin component in the
coating for further enhancing release properties. In
a preferred embodiment, the wax component is a
20 polyethylene wax. The coating 20 is preferably applied
by gravure coating techniques and dried in air in a
drying oven at approximately 220° to 250° F to cross-
link the resin and bond the release coat to the
carrier. In some instances, such as dry paint transfer
25 laminating steps in which the primer coat is
transferred to a high temperature-resistant polymer
sheet such as polyarylate, the release coat (including
its thermoset resin component) can be omitted.

The conductive primer coat 24 is then coated on
30 the release coated carrier. The conductive primer
preferably comprises a thermoplastic synthetic resinous
material containing a sub-micron size filler such as
carbon for providing electrically conductive particles
uniformly dispersed throughout the resin. The
35 preferred conductive filler is carbon black. The
conductive primer is a flexible synthetic resinous dry
film-form coating having electrically conductive

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1 properties described below. In some cases the
conductive primer can comprise a lightly cross-linked
thermosetting resin to increase the temperature
resistance of the primer coat. In either case, the
5 resinous conductive coating is flexible (or
thermoplastic as defined herein) in the sense that it
is thermoformable, i.e., able to be elongated under
heat without cracking or degrading its conductivity.
Use in an SMC process, vacuum forming contact with a
10 heated tool, or other high temperature mold face
applications can require a higher temperature
resistance of the finished primer coat. The resin is
dissolved in a suitable organic solvent and applied as
a thin uniform film coating. The conductive coating is
15 then dried by solvent evaporation at elevated
temperatures to cure and harden the resin and form a
thin, flexible, continuous uniformly conductive primer
coat across the surface area of the release coated
carrier. The base resin can be modified to accommodate
20 adhesion to different plastics. In addition, other
conductive materials such as graphite, nickel, copper,
silver coated glass beads, nickel coated graphite
fibers, and a metal flake known as Metalure (a
trademark of Avery Dennison) can be added to the
25 resinous primer base to alter conductivity as desired.
A minor amount of an anti-blocking agent such as fumed
silica is dispersed in the mixture. The dispersion is
reduced to press viscosity with the organic solvent
until a viscosity of about 1,000 cps is achieved at
30 approximately 24% solids. A suitable organic solvent
can be a 1:1 mixture of methyl-ethyl-ketone (MEK) and
toluene. To assure that the lacquer meets conductivity
requirements, the surface resistivity is preferably
checked with both an ohm/volt meter and a Ransberg
35 Model 236 sprayability meter. The ohm/volt meter
should preferably read in the range of 5 K-ohms to 50
K-ohms/inch. The Ransberg measurement should be

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1 greater than about 110 units. The lacquer can be
checked by drawing down small samples, baking them at
200° F for four minutes to drive off the solvent, and
then measuring the conductivity. Once conductivity
5 requirements have been met, the conductive primer coat
can be applied to the matte release carrier.

FIG. 3 shows in more detail a first step in the
process which includes coating the matte release coat
in thin film form onto the surface of the temporary
10 carrier film. The film thickness of the carrier film
is less than about two mils, and is preferably about
0.48 to about 0.75 mil thick. The carrier film also
has a film thickness which provides sufficient strength
to permit its release from the conductive coating.

15 The carrier film is contained on a supply roll 38
from which the carrier is unwound, passed around an
idler roller 40, and then passed to a gravure print
station 42 where the matte release coat is gravure-
coated onto the carrier film by a conventional gravure
20 cylinder 44. The carrier film containing the matte
release coat is then passed through a first drying oven
46, preferably a 20-foot long impinging air oven
operated at a temperature from about 325° to about 350°
F, sufficient for drying and cross-linking the matte
25 release coat 20. In the first stage drying oven, the
matte release coat is sufficiently cross-linked to
permanently bond it to the carrier sheet. Preferably,
the matte release coat is coated and dried to produce
a coat weight (dry) from about 3 to about 5 gr/m².

30 The carrier containing the matte release coat
which has been dried and cross-linked exits the first
stage oven 46 and is then passed to a reverse-roll
coater station 48 for coating the conductive primer
coat 24 onto the dried matte release coat. The
35 conductive primer coat is then passed to a second
drying oven 50, preferably a 120-foot long impinging
air oven. This oven can be in multiple stages with

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1 drying zones of different controlled temperatures,
depending upon the drying characteristics of the
conductive primer coat. Preferably, the cast
conductive primer coat, described below, is dried at an
5 oven air temperature of about 250° - 350° F, depending
on resin selection, to form an essentially solvent free
($< 0.3\%$ by weight) electrostatically sprayable and
electrically conductive coat on the matte release film.

The dried, conductive-coated film 51 is removed
10 from the second drying oven 50 and wound onto a rewind
roll 52 at the output of the first coating stage.

The conductive coated side of the film can be
coated with the size coat 27 for use in later bonding
the conductive layer to a face sheet during a
15 transfer-lamination stage of the process. For certain
lamination sheets and laminating conditions the size
coat may be omitted.

The film containing the dried conductive coat
passes from the second drying oven 50 to a gravure
20 print station (not shown) where an optional size coat
25 is coated on the dried conductive coat. The size
coat is then passed through an impinging air oven (not
shown) operated at a temperature of about 250° F for
drying the size coat 25. The size coat is applied
25 using a gravure cylinder and can contain a pigment up
to about 25% by volume, although less than 10% by
volume is preferred. The dried coat weight of the size
coat ranges from about 1 to about 3 gr/m².

The size coat 25 can comprise any of various
30 suitable coating compositions to provide adhesion of
the conductive film to the face sheet 26 during the
transfer-lamination step carried out later during the
process. The size coat preferably comprises a suitable
thermoplastic resinous material such as an acrylic
35 resin. In one embodiment, the size coat comprises a
polymethylmethacrylate or polyethylmethacrylate-
containing resin.

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1 In certain instances in which the face sheet 26
may be made from a thermoplastic polyolefin such as
polypropylene or polyethylene, a different size coat
can be used. In this instance, the size coat is
5 preferably made from a coating composition of a
solution of a thermoplastic chlorinated polyolefin
(CPO). A preferred CPO size coat preferably is a
chlorinated polypropylene or chlorinated polyethylene,
in which the coating composition contains about 10% to
10 about 60% by weight of the CPO, and correspondingly,
about 40% to about 90% by weight solvent.

 Following drying of the size coat 25, the
conductive film exits the drying oven and is wound on
a supply roll (not shown). The completed foil is then
15 removed from the coating system and installed at the
unwind of a transfer-laminating station for removing
the conductive primer 24 and size coat 25 from the
release-coated carrier and transferring the primer to
the surface of the face sheet 26. This step can be in
20 several alternatives. An extruder-laminator can be
used, in which the face sheet 26 is extruded, while
simultaneously, the conductive primer film is laminated
to the extruded sheet, using the heat and pressure
generated from the extruder die exit and calander and
25 transfer rolls to heat-bond the primer film to the
sheet. This approach is shown in FIG. 11 and described
in more detail in Example 15. When the conductive foil
is pressed into contact with the extruded sheet, the
extrusion temperature is also sufficiently elevated to
30 bond the foil to the extruded sheet. The matte release
coated polyester carrier sheet has a heat resistance
sufficient to resist elongation or deformation during
the transfer and lamination step. Following the
lamination step, the flexible, laminated extruded film
35 undergoes controlled cooling. A series of water-cooled
chill rollers (not shown) produce a controlled
temperature reduction in the laminate.

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1 Alternatively, an existing primer-coated face
sheet can be extrusion cap laminated to an extruded
sheet as shown in FIG. 10 and described in more detail
in Example 10. This technique is also shown generally
5 in FIG. 2 in which the extruded substrate 28 is a
multi-layer extrusion. In some instances, particularly
those involving high temperature engineering plastics
such as polyarylates in a multi-layer substrate form,
adhesion is obtained without the size coats 25 or 27.

10 As another alternative, the conductive primer can
be laminated to an existing semi-flexible plastic face
sheet by a dry paint transfer-lamination step described
in Example 1.

 When the carrier is removed from the laminate, the
15 matte release coat, which has been cross-linked and
permanently bonded to the carrier sheet, remains
adhered to the carrier film during the stripping
process. The matte release coat has a matte outer
surface with a micro-roughness which is transferred to
20 the conductive primer coat. The micro-roughness of the
matte coat is replicated to transfer a sufficiently low
gloss to the primer coat to enhance spray paint
adhesion. The desired gloss level can vary. The
formulation of the matte release coat (described below)
25 provides a combination of the desired low gloss
surface, together with a smooth or free release of the
carrier sheet from the low gloss surface at any
stripping temperature.

 The matte release coat formulation comprises a
30 coating which can be applied to the carrier by
conventional casting techniques, such as gravure or
roller coating. The preferred coating composition is a
thermosetting resinous material which, when exposed to
heat for drying it, also cross-links and permanently
35 bonds as a surface film adhered to the carrier sheet.
The solids contained in the matte release coat
preferably include, as a principal component, one or

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1 more cross-linking agents to provide good adhesion of
the dried cross-linked coating to the polyester carrier
film. In one embodiment, the matte release coat
formulation includes a primary cross-linking resin such
5 as a vinyl resin that bonds to the polyester film. A
suitable vinyl resin is a medium molecular weight
vinylchloride-vinylacetate resin known as VAGH,
described in more detail in Example 1 below. This
vinyl resin can be present in an amount up to about 20%
10 of the total solids in the matte release coat. In
addition, the matte release coat can include a
secondary cross-linking resin to improve release of the
conductive coat from the matte release coat. In one
embodiment, the secondary cross-linking resin can be an
15 acrylic modified alkyd resin such as the resin known as
Chempol 13-1501 also described in more detail in
Example 1. This secondary cross-linking resin
comprises from about 1% to about 15% of the total
solids of the matte release coat. The matte release
20 coat further includes a suitable catalyst for
accelerating the cross-linking process, typically
comprising from about 1% to 2% of the total solids in
the matte release coat.

The resinous components of the matte release coat
25 composition are mixed with suitable organic solvents.
In one embodiment, the resins are mixed with a primary
resin solvent such as methyl isobutyl ketone (MIBK)
which comprises about 80% to about 95% of the total
solvent in the formulation. A secondary resin solvent
30 such as isopropyl alcohol (IPOH) is useful in retarding
cross-linking of the resins in solution. The secondary
resin solvent preferably comprises from about 5% to
about 20% of the total of solvent.

The matte release coat formulation is prepared by
35 dissolving the primary cross-linking resin in the
primary and secondary resin solvents by mixing and then
adding the secondary cross-linking resin, together with

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1 a primary matting agent, preferably in the form of a
filler comprising a fine particulate inert inorganic
material. In one embodiment, the filler comprises
5 aluminum silicate with an average particle size of
about 5.0 microns. The filler contained in the
formulation comprises up to about 25% of the total
solids in the matte release coat. The fine particulate
filler is thoroughly dispersed in the resin and resin
10 solvent blend, preferably under elevated temperatures
from about 100° to about 120° F.

When the matte release layer dries and
cross-links, it forms a matte coating on the surface of
the carrier sheet. The thermoset resinous coating is
continuous with the face of the carrier sheet, and in
15 its cross-linked and permanently bonded dry film form,
it provides a high temperature resistant thermal
transfer barrier between the polyester carrier sheet
and the primer coat and its underlying substrate. The
matte surface is controlled by the amount and particle
20 size of the filler. The fine particles in the matte
release coat form, on a microscopic scale, a surface
with a micro-roughness that transfers a replicated
micro-roughness to the surface of the dried conductive
coat.

25 The matte release coat formulation may include a
release agent to enhance freely releasing the carrier
and its matte release coat from the conductive coat
during the transfer process. The release agent
preferably includes a wax component such as a
30 polyethylene wax which melts at elevated temperatures
to allow easy hot release of the release coat. The wax
component is normally suspended in the matte release
coat at 100° - 120° F; and the wax component, in its
suspended or particulate form, also acts as a matte
35 agent. The preferred polyethylene wax is Shamrock S-
381-N1 (described in Example 1 below). In one
preferred form of the release coat formulation, the

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1 polyethylene wax comprises from about 0.1% to about 25%
of the solids contained in the matte release coat.

5 The release agent contained in the matte release
coat formulation may further include a silicone resin
component which combines with the polyethylene wax to
enhance free release of the conductive coat from the
matte release coat at temperatures ranging from room
temperature to elevated. In one embodiment, the
silicone resin comprises from about 0.5% to about 25%
10 of the solids contained in the matte release coat
formulation. Release is improved when the wax and
silicone resin are used in combination in the matte
release coat.

15 In one embodiment, the conductive primer coat is
a thermoplastic synthetic resinous coating composition.
The preferred dry film thickness of the conductive coat
is from about 0.3 to about 1.5 mils. Preferably, the
conductive primer coat lacquer formulation produces a
dry film coating having desired properties of
20 electrical conductivity, resistance to spray paint
solvents, and adhesion to sprayed paints and primers,
resulting in a Class "A" surface after electrostatic
paint spraying. The electrically conductive polymeric
material, in one embodiment, includes a polyester resin
25 containing a fine particulate conductive material, such
as carbon black, and an anti-blocking agent, such as a
dispersion of fumed silica. Other thermoplastic
resinous materials can be used such as acrylics,
polyurethanes, polyarylates, polycarbonates, and
30 polyetherimides.

In one embodiment, a principal component of the
resin contained in the conductive primer coat is a
polyester resin, such as Adcote X80-125 (a trademark of
Morton International of Chicago, Illinois). In its
35 preferred form, the polyester component comprises from
about 50% to about 90% of the total solids contained in
the conductive coat formulation, preferably from about

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1 70% to 85%. The lower limit is governed by the
cohesive strength of the dried film and the upper limit
is governed by the conductivity required. In one
embodiment, the conductive coating is lightly cross-
5 linked, as mentioned previously, to increase the
temperature resistance of the finished primer, as
described below in Example 15.

A second component is a conductive pigment,
preferably a carbon black, and most preferably Vulcan
10 XC-72 a trademark of Cabot Corp. In its preferred form
the carbon black comprises from about 10% to about 50%
by weight of the solids contained in the conductive
primer. The lower limit is governed by the surface
conductivity of the finished dried conductive primer
15 film which will allow electrostatic painting.

The third, and optional, component is a
particulate antiblocking agent, preferably a fumed
silica, most preferably the material sold under the
designation TS-100, a trademark of DeGussa. In its
20 preferred form, the fumed silica comprises from 0% to
about 5% by weight, most preferably 2% to 3% by weight,
of the total solids in the conductive primer. Too much
antiblocking agent reduces the conductivity of the
finished, dried conductive primer film.

25 A preferred formulation contains 27 parts Adcote
X80-125 polyester resin (dry), solvents MEK and toluene
32.6 parts each, 6.8 parts Vulcan XC-72 carbon black,
and one part TS-100 fumed silica.

Other minor components of the conductive coat
30 formulation may include a dispersing agent, such as the
material sold under the designation FC-430, a trademark
of 3M Co. The dispersing agent preferably comprises up
to about 0.05 parts per 100 parts resin.

35 Example 1

A plastic car body panel was made by the following
steps: (a) preparing a matte release film; (b)

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- 1 preparing a conductive primer film; (c) preparing a
 conductive transfer foil; (d) transfer to a
 thermoformable backing sheet; (e) thermoforming; and
 (f) bonding of the thermoformed laminate to a substrate
 5 panel.

a. Matte Release Coat

A matte release coat was formulated from the
 following components:

10

	<u>Component</u>	<u>Parts</u>
Composition 1:	Methyl isobutyl ketone (MIBK)	42.4
	Isopropyl alcohol (IPOH)	7.8
	VAGH	10.2
	ASP400	26.3
	Chempol 13-1501	12.7
	S381-N1	0.6
		<u>100.0</u>
Composition 2:	Methyl isobutyl ketone	56.7
	Isopropyl alcohol	9.0
	VAGH	15.1
	Chempol 13-1501	19.2
		<u>100.0</u>
Release Coat:	Composition 1	25.35
	Composition 2	54.83
	SR107	0.86
	MIBK/IPOH Blend (85/15)	7.56
	Cycat 4040	4.2
	Cymel 303	7.2
		<u>100.00</u>

- 25 1. VAGH is a medium molecular weight, partially
 hydrolyzed vinyl chloride-vinyl acetate resin
 (approximately 90% vinyl chloride, 4% vinyl acetate and
 a hydroxyl content of 2.3%) sold by Union Carbide,
 Somerset, New Jersey.

- 30 2. ASP400 is an aluminum silicate of average
 particle size five microns made by Engelhard Corp.,
 Edison, New Jersey, and sold by Jensen-Souder, Itasca,
 Illinois.

- 35 3. Chempol 13-1501 is an acrylic modified alkyd
 resin solution (50% resin, 50% xylol) sold by Freeman
 Chemical Co., Port Washington, Wisconsin.

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1 4. SR-107 is a silicone resin manufactured by
General Electric, Waterford, Connecticut, and sold by
Fitzchem, Chicago, Illinois.

5 5. S381-N1 is a polyethylene wax sold by
Shamrock Chemicals Corp., Newark, New Jersey.

6. Cycat 4040 is a para toluene sulfonic acid
catalyst (40% by weight in isopropanol) sold by
American Cyanamid Co., Walingford, Connecticut.

10 7. Cymel 303 is a liquid hexamethoxy-
methylmelamine cross-linking agent sold by American
Cyanamid.

Composition 1 was produced by dissolving the VAGH
resin in an MIBK and IPOH blend by mixing in a Cowles
mixer and then adding the Chempol 13-1501, ASP400 and
15 the S381-NI while mixing. This mixture was then
sandmilled at a temperature of about 110° F to disperse
the ASP400.

b. Conductive Primer Coat

20 A conductive primer coat was formulated as
follows.

16.5 parts of methyl ethyl ketone (MEK) and 16.5 parts
of toluene were mixed in a vessel. 58 parts of the
polyester resin solution were slowly added while
25 mixing. After the mixture was homogeneous, 9 parts of
Vulcan XC-72 carbon black were slowly added. This
premix was then milled to a grind of less than 5
microns in a shot mill (1 mm shot). Any solvent loss
during milling was brought back to its original weight,
30 and the batch was labeled Batch A. 96 parts of the
polyester resin solution were added into a separate
vessel and mixed while slowly adding 4 parts fumed
silica. The mixture was dispersed to a grind of 30
microns and labeled Batch B. Three parts Batch A and
35 one part Batch B were mixed until a homogeneous state
was achieved.

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1 8. The polyester resin solution comprised Adcote
X80-125 which was at 40% solids in a 50:50 blend of MEK
and toluene.

5 9. Vulcan XC-72 is a high surface area
conductive carbon black of average particle size of 30
nm sold by Cabot Corp. of Waltman, Massachusett

10 10. The fumed silica was TS-100 with an average
particle size of 5 microns, sold by Degussa Corporation
of Teterboro, New Jersey.

10

c. Preparation of the Conductive Transfer Foil

The matte release coat was gravure coated in
uniform film thickness onto the carrier with a 100 HK
gravure cylinder pattern at a coat weight (dried) of 3
15 gr/m². The carrier was 75 gauge oriented gloss
polyester carrier sheet (Hostaphan 2000, sold by
Hoechst Celanese, Greer, South Carolina). Line speed
was 200 feet per minute and the coating was dried and
cross-linked in a 20 foot impinging-air oven (Oven No.
20 1 in FIG. 3) at an air temperature of 340° F (web
temperature approximately 220° F). This formed a
continuous, uniform high temperature resistant matte
release film permanently bonded to the carrier sheet.

25 Next, the conductive primer coat was coated at a
coating weight (dried) of 22 gr/m² onto the dried matte
release coat in a reverse-roll coater station on the
same coater. The primer coat was of continuous,
uniform film thickness and was dried and fused in a 120
foot three-zone impinging air oven with the air
30 temperatures in the three zones being 200° F, 230° F,
and 250° F. This formed a dried conductive primer coat
on the matte release coat of the carrier film.

35 To minimize web shrinkage and avoid distortion of
the carrier film, web tension was maintained below 0.8
lbs/linear inch of web width through the drying ovens.

The dried, coated primer film was wound as a roll,
and removed from the coater.

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1 d. Transfer to Thermoformable Backing Sheet

 The conductive primer-coated carrier was next laminated to the thermoformable face sheet 26 by dry paint transfer-laminating techniques illustrated in FIG. 4. The thermoformable laminate 56 formed by the transfer-lamination step includes the composite conductive primer layer 24 adhered to the face sheet 26. The face sheet is preferably a semirigid, self-supporting, thin, flat sheet of a synthetic resinous material. The face sheet is made from a material which is compatible with an injection-molded plastic material or thermosetting fiber filled molding compound later used to form the structural substrate base 28 of the finished article, or the face sheet is compatible with another polymeric laminate to which it is adhered when the total structure is vacuum pressure formed as an alternative technique for forming the finished panel. Preferably, the face sheet is made from the same or substantially the same polymeric material as the substrate base of the finished article. The face sheet also is made from a material having a thickness capable of thermoforming into a complex three-dimensional shape, along with the adhered composite conductive primer coat, without substantially affecting the conductivity of the conductive primer. The material from which the substrate is molded can contain a substantial amount of large fibers or particulate filler and therefore can produce an imperfect surface on the final painted article molded from the substrate material. The laminate is adhered to the otherwise imperfect surface of the molded substrate to improve the surface characteristics of the substrate panel and produce a uniform conductive primer which, when electrostatic spray painted with an exterior automotive paint, produces an outstandingly smooth controlled exterior Class "A" automotive finish. The properties of a Class "A" exterior automotive paint surface are

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1 described generally in PCT Application No. WO 88/07416,
incorporated herein by this reference. The
multi-layered article in its finished form comprises a
high-performance, essentially defect-free,
5 three-dimensionally shaped paint coat with exterior
automotive properties in combination with the backing
sheet, which provides a buffer layer between the
substandard surface of the substrate and the finished
paint coat. The face sheet material minimizes the
10 surface imperfections transmitted to the paint coat.
The preferred materials from which the face sheet is
made are ABS (acrylonitrile-butadiene-styrene),
polycarbonate, a polyester known as Xenoy (a trademark
of G.E.), a polyetherimide known as Ultem (a trademark
15 of G.E.), a modified phenylene oxide known as Noryl (a
trademark of G.E.), polyarylate, TPO, nylon, vinyl
(PVC), and GTX urethane acrylic polycarbonate. A
preferred ABS material is Borg Warner's Cycolac L.S.
Thermoplastic polyolefins (TPO's) including
20 polypropylenes and polyethylenes may be used, as well
as polyesters or an amorphous nylon, such as Bexloy C-
712, a trademark of Du Pont.

The thickness of the face sheet can vary, but
generally it is necessary for the face sheet to have a
25 sufficient thickness to isolate or absorb imperfections
in the surface of the underlying substrate while
presenting a smooth upper surface of the paint coat
after painting. A desirable range of thickness of the
face sheet is believed to be from about 10 to 200 mils,
30 with 20 mils being a preferred thickness for an ABS
sheet when used in thermoset or thermoplastic molding,
for example. The thicker laminates are preferred for
VPF (vacuum pressure forming) operations.

The laminating step illustrated in FIG. 4 shows
35 the conductive-coated carrier 60 stored on a top unwind
roll 62 and a flexible 20 mil thick ABS face sheet 24
stored on a bottom unwind roll 64. The conductive-

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1 coated carrier, in one embodiment, comprises the
conductive primer coat on a single flexible matte
release-coated casting sheet. The conductive-coated
5 casting sheet 60 is passed around a drum 66, and the
face sheet passes around a drum 68. The carrier and
backing sheet then pass between a heated laminating
drum 70 and a rubber backup roll 72. The laminating
drum is preferably made of steel and is preferably
10 operated at a temperature of about 400° to 425° F. It
is pressed into contact with the overlapping sheets to
heat them to a temperature sufficient to melt the
release agents in the matte release coat to release the
primer from the carrier and to bond the conductive
15 primer coat to the face sheet. The rubber backup roll
72 and laminating drum 70 are in pressure contact with
the carrier and backing sheet preferably at a pressure
of about 300 pounds per lineal inch. The speed at
which the sheets travel during laminating ensures that
20 the resulting laminate is heated to a temperature
necessary to effect transfer and bonding. The heat
softens the face sheet material somewhat to ensure a
complete bond between the conductive coat and the face
sheet. The polyester carrier sheet of the conductive
25 matte release-coated carrier has a heat-resistance
above laminating temperatures so the carrier sheet
resists elongation during the laminating step. During
the transfer step the micro-roughness of the matte
surface on the carrier is transferred to the surface of
the primer coat. Following the bonding step, the
30 flexible conductive-coated laminate is then passed
around one or more chill rollers 74 for cooling the
laminate to room temperature. The finished laminate 56
then passes onto a laminate rewind drum 76. The
carrier sheet may be stripped away from the laminate
35 prior to the subsequent thermoforming step or may
remain attached. Other polymeric films or laminates

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1 may also be similarly transfer-laminated to the
finished conductive laminate.

e. Thermoforming

5 In the next step in the process, the laminate 56
shown in FIG. 4 was thermoformed into a desired three-
dimensional shape. The thermoforming step is
illustrated in FIGS. 5 and 6 in which the initially
flat laminate is formed into a highly contoured three-
10 dimensional shape for use as the surface of a car body
panel. Separate laminate sheets are individually
placed inside a clamping frame 78 of a vacuum-forming
machine. The clamping frame is movable back and forth
on a track 80. The laminate sheet is initially placed
15 in the clamping frame at the position shown in FIG. 5.

The clamping frame is then moved along the track
into an oven 82 for heating the back sheet to a
thermoforming temperature. The ABS face sheet is
heated to a temperature in the range of about 280° to
20 about 380° F. For a Bexloy nylon the sheet is heated
to a temperature from about 380° to about 420° F.
These temperatures are actual sheet temperatures, not
oven temperatures. A pressure assist can be used with
the thermoforming step in order to reduce the
25 thermoforming temperature. At thermoforming
temperatures the laminate sags as shown at phantom
lines at 84.

After the laminate is heated in the oven to the
desired temperature, the clamping frame is moved back
30 along the track 80, away from the oven 82 and to its
original position above a vacuum-forming buck 86. The
working surface of the vacuum-forming buck 86 is shown
as a curved surface, by way of example only. Other
configurations can be used depending upon the desired
35 three-dimensional shape imparted to the surface of the
finished article.

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1 The preheated laminate is next vacuum-formed into
the desired three-dimensional shape by first drawing a
vacuum on the vacuum-forming buck through its
connection to a vacuum pump 88. The vacuum-forming
5 buck is then raised to the position shown in FIG. 6,
where it has risen into the clamping frame. The vacuum
is pulled through holes in the buck to force the hot
plastic into the shape of the working surface of the
buck. Positive air pressure can be applied to the free
10 face of the primer coat on the opposite side of the
buck to increase forming pressure. The buck stays in
place long enough to cool the plastic to a solid state
again before the buck drops away back to the position
shown. This leaves behind the plastic in the shape of
15 the buck. The preferred vacuum-forming step is to use
a male vacuum former in which the vacuum-forming buck
is in direct contact with the face sheet so as to not
contact the exterior conductive coat on the opposite
side of the backing sheet. In this way, the face sheet
20 hides most of any of the possible defects in the
working surface of the buck; and the surface of the
conductive coat is not affected, but is allowed to
elongate freely. Female molds can also be used
successfully.

25 In an alternate thermoforming step (not shown),
the laminate can be fed to the thermoformer as a
continuous sheet. The laminate first passes through
the oven and then passes to the thermoforming buck in
line with the downstream end of the oven. The
30 continuous sheet is stopped at preset intervals for
heating the laminate to the thermoforming temperature
while a previously heated portion of the sheet is
vacuum formed into the desired shape.

 The thermoforming step produces a three-
35 dimensionally shaped preformed laminate shown at 90 in
FIG. 7. For simplicity, the preformed laminate is
illustrated as comprising the face sheet 26 and the

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1 conductive primer coat 24 adhered to it. The laminate
is illustrated in a three-dimensionally shaped form
following the thermoforming step as one example only of
a possible three-dimensional shape. Other complex
5 three-dimensional shapes are also possible. The
conductive coating experiences elongations greater than
about 150% during thermoforming without significantly
affecting the uniformity of conductivity and the
ability to electrostatically spray paint it to achieve
10 a Class "A" surface.

(f) Bonding of Thermoformed Laminate to Substrate Panel

A subsequent injection-cladding operation is shown
15 in FIGS. 7 and 8 in which the preformed laminate 90 is
adhered to an underlying plastic substrate panel 28.
The injection-cladding step is an example of a possible
means for adhering the laminate to the substrate.
After the laminate 90 is preformed to its desired
20 shape, it is trimmed to size and is ready for
injection-cladding. The thermoformed laminate 90 is
placed in an injection mold 92 and fused to the face of
an injection-molded substrate. According to a first
step in the injection-cladding step, a plastic
25 injection mold is in its open position, and the
preformed laminate is placed in a mold cavity 94
between front and rear mold halves 96 and 98. The
inside surface 100 of the mold half identically matches
the exterior contour of the conductive primer-coated
30 surface of the preformed laminate 90. This surface of
the mold is a rigid surface which is free of surface
defects so that surface defects are not transferred to
the conductive-coated surface of the laminate. After
the vacuum-formed die cut sheet 90 is placed inside the
35 injection mold, a space is left behind the laminate for
receiving the injection molding material 102. The
injection molding material flows through a passage 104

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1 in the rear mold half and into the mold cavity behind
the preformed laminate. The molding material conforms
to the shape of the mold cavity and is permanently
fused to the face sheet portion of the laminate. The
5 injection molding material does not come into contact
with the conductive coat. As described previously, the
molding materials from which the substrate and the face
sheet are made are compatible so that the two materials
fuse to form an integral molded substrate on which the
10 conductive coat provides a defect-free finish. The
temperature at which the injection-mold is operated is
substantially below the melt temperature of the
molding material. In one embodiment, in which an ABS
backing sheet was used, the molten material was at a
15 temperature of about 450° F, for example. A water
jacket can be used to cool the faces of the mold. Both
faces of the mold are cooled to a temperature in the
range of about 160° to 170° F, so that the conductive
primer coat on the laminate remains stable during
20 injection molding. A lightly cross-linked or more
temperature-resistant resin can be used at higher mold
temperatures.

The finished article produced by the process of
this invention includes the preformed laminate 90 and
25 its face sheet 26 which have been fused to the molded
substrate. In one embodiment, the article can be a
conductive primed exterior car body member or panel.
Any defects in the substrate material have been
absorbed by the 20 mil thick face sheet to provide a
30 defect-free conductive coat 22.

Although this example has been described with
respect to the illustrated thermoplastic injection-
molding steps, other techniques can be used for forming
the finished article. These include, but are not
35 limited to, fiber reinforced thermoset injection
molding (TMC), use of sheet molding compounds (SMC),
compression cladding and reaction injection molding

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1 (RIM) and resin transfer molding (RTM) techniques,
vacuum pressure forming, and pressure-sensitive or
adhesive bonding techniques. Other plastic molding
materials also can be used in place of ABS for fusing
5 the substrate panel to the primer-coated face sheet.
These may include thermoplastic polyolefins (TPO's)
such as polypropylenes and polyethylenes; polyesters;
and amorphous nylon. In these instances, the face
sheet is preferably made from the same polymeric
10 material as the injection molding material.

Example 2

The conductive coating in the polyester resin
system from Example 1 was coated as a uniform film 0.8
15 mils thick on the matte release coated polyester film
in Example 1 and then laminated to a 20 mil thick ABS
face sheet.

The following table shows resistivity measurements
in Ransberg units, K-ohms/in., and K-ohms/sq.

20

<u>Film Thickness</u>	<u>Ransberg</u>	<u>K-ohms/in.</u>	<u>K-ohms/sq.</u>
0.8 mils	165+	37	26

Example 3

25 The conductive coating in the polyester resin
system from Example 1 was coated as a film 0.5 mil
thick on the matte release coated polyester film in
Example 1 and then laminated to a 20 mil thick ABS
backing sheet.

30 The following table shows resistivity measurements
in Ransberg units, K-ohms/in., and K-ohms/sq.

<u>Film Thickness</u>	<u>Ransberg</u>	<u>K-ohms/in.</u>	<u>K-ohms/sq.</u>
0.5 mils	165+	45	32

35

In both Examples 2 and 3, the coating resulted in
a surface that is electrostatically sprayable. To be

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1 considered electrostatically sprayable a Ransberg
reading greater than about 110 units is required.

5 The most practical method to determine
electrostatic sprayability is with the Ransberg 236
sprayability meter. Two conductive probes that are one
inch apart contact the surface under test. The
measurement is activated by depressing a button on the
hand-held gauge and an electrical charge is passed from
one probe to the other. The reading is recorded in
10 Ransberg units. Any reading below 110 units is
considered a surface that is not electrostatic
sprayable.

Another method for calculating the surface
resistivity is by the use of a Micronta 22-201U
15 ohm/volt meter. The preferred method is by point to
point readings recorded by fixing the distance of the
point probes at exactly one inch apart, contacting the
test surface with the probes, and recording the
resistivity in K-ohms/inch. The most preferred method
20 is by fixing two one-inch by 1/8-inch copper bars on a
1-1/4 inch square block of non-conductive plastic such
as plexiglass. The bars are parallel, one inch apart.
The copper bars serve as contact points for the surface
to be measured. Each bar is wired into the ohm/volt
25 meter and a 500 gram weight is placed on the top of the
plexiglass before the reading is recorded in
K-ohms/square.

Example 4

30 A series of conductive coatings were formulated at
different carbon black pigment to polyester resin
ratios. The conductive coatings were applied to a
matte release liner as described in Example 1 and
laminated to a 20 mil thick ABS sheet. The conductive
35 film thickness was 0.8 mils. The carbon black was
Vulcan XC-72. The following table shows surface
resistivity measurements as a function of

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- 1 pigment/binder (or resin) ratios. The ratio is determined on the basis of a dry film resin.

	<u>P/B Ratio</u>	<u>Ransberg</u>	<u>K-ohms/in</u>	<u>E.S. Sprayable</u>
5	0.2308	+165	25	Yes
	0.2129	+165	46	Yes
	0.1953	+165	97	Yes
	0.1778	164	378	Yes
	0.1606	147	500	Yes
	0.1416	140	500	Yes
	0.1211	131	500+	Yes
	0.0895	87	500+	No

10 Example 5

Standard Cabot Vulcan XC-72 carbon black having a surface area of 254 M²/gm was compared to two other Cabot lower surface area carbon blacks. Mongul L having a surface areas of 138 M²/gm and Vulcan PA-74 having a surface area of 140 M²/gm were formulated at 7 parts carbon black per 30 parts polyester resin. The formulas were milled with 1/8 inch shot on a lab scale paint shaker for three hours. The coatings were applied to the matte release liner as described in Example 1 at a thickness of 0.8 mils.

The following results represent carbon black type vs Ransberg units measurements:

	<u>Carbon Type</u>	<u>Ransberg</u>	<u>E.S. Sprayable</u>
25	Mongul L	81	No
	Vulcan XC-72	165+	Yes
	Vulcan PA-74	82	No

It was concluded that carbon black having a surface area greater than about 200 m²/gm would produce the highest and most consistent conductivity.

30 Example 6

Conductive materials other than carbon black were formulated. U.S. Bronze Powder Palegold B620 and Potter Labs ESD fiber batch 91-100-4.6.7 were substituted in the polyester resin of Example 1 at a

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1 concentration of 30% by weight (dry). After the
mixture was homogeneous, the solutions were coated at
a film thickness of 0.8 mil. The following results
show material type compared with Ransberg units of
5 conductivity:

<u>Material Type</u>	<u>Ransberg</u>	<u>E.S. Sprayable</u>
Bronze Powder	80	No
ESD Fiber	82	No

10

Example 7

Samples of the conductive coating of Example 1
with U.S. Bronze Powder Palegold B620 added at 50% and
67% by weight levels in place of the carbon black were
15 applied to matte release liner as described in Example
1 at a film thickness of 0.8 mils and laminated to a 20
mil thick ABS sheet. Similar samples were made with no
conductive filler, with carbon black as the conductive
filler, and with Metalure as the conductive filler.
20 The Metalure material was Avery Dennison product no. L-
55350. The samples were measured for EMI/RF shielding
properties with a Bekiscan CP2 instrument. The
Bekiscan CP2 microwave reflection analyzer is a non-
destructive method of testing EMI/RF shielding
25 effectiveness for plastic parts. Good commercial
products have reflection measurements in a range above
about 70%. The following table shows the test results:

30

35

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1			
	<u>Sample</u>	<u>Shielding At 10 Ghz</u>	<u>K-ohms/sq.</u>
	ABS Only	0% Refl.	>10 ¹²
5	Conductive Coat with carbon black on ABS	0% Refl.	10.0
	Conductive Coat with 50% by weight bronze powder	48% Refl.	0.21
	Conductive Coat with 67% by weight bronze powder	71% Refl.	0.12
10	Conductive coat with Metalure at 30% by weight	90% Refl.	N.A.

Good results were obtained with the greater sized Metalure flakes which are high aspect ratio vacuum metallized aluminum flakes with an average major dimension of about ten microns.

Example 8

The conductive laminate of Example 1 was formed on a 20 mil thick ABS sheet. The laminate was vacuum formed (on a Packaging Industries continuous feed vacuum former) into a vacuum formed shell. The shell was injection molded with ABS in an injection molding machine. The resulting substrate was shaped as a finished door trim panel. The following table lists the resistivity measurements on the surface of the finished part:

	<u>Part</u>	<u>Ransberg</u>	<u>K-ohms/in.</u>	<u>K-ohms/sq.</u>	<u>Sprayable</u>
30	Trim	165+	10.3	7.1	Yes

Example 9

A conductive coating as described in Example 1 was applied to a matte release liner as described in Example 1 and laminated to a 20 mil thick ABS sheet and a 20 mil thick Ultem sheet. Each construction was vacuum formed with a three-step tool that simulated

-38-

1 three different depths of draw or elongation. The
 following table shows surface resistivity measurements
 as a function of depth of draw or final film thickness
 of the conductive coating:

5

ABS 20 Mil

	<u>Depth of Draw</u>	<u>Film Thickness</u>	<u>Ransberg</u>	<u>K-ohms/in.</u>	<u>E.S. Sprayable</u>
	Lo	0.8 mil	165+	35	Yes
10	Med	0.6 mil	165+	38	Yes
	Hi	0.5 mil	165+	45	Yes

Ultem 20 Mil

	<u>Depth of Draw</u>	<u>Film Thickness</u>	<u>Ransberg</u>	<u>K-ohms/in.</u>	<u>E.S. Sprayable</u>
	Lo	0.8 mil	165+	35	Yes
15	Med	0.6 mil	165+	45	Yes
	Hi	0.4 mil	165+	55	Yes

20 After recording data, the conductive coated vacuum
 formed laminate was electrostatically spray painted.
 The paint used was received directly from the GM
 assembly paint line at the Cadillac assembly plant in
 Lake Orion, Michigan. The following table lists the
 individual paints:

25

	<u>Paint</u>	<u>Identification</u>	<u>Film Thickness</u>
	Grey Prime	PPG Code 13 Prime 1146-9855 Lot 19563	1.2 mils
	Base Coat	PPG Code 22 Blue Met 8966 Lot 17733	0.9 mils
30	Urethane Clear Coat	Part A - PPG NCT 2BR Lot 19261	1.9 mils
	Urethane Clear Coat	Part B - PPG NCT 2AV Lot 18423	

35 The urethane is a clear coat system that is
 catalyzed when both components are mixed and sprayed to
 form a hard clear coat.

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1 The following table represents a GM paint cycle
the conductive finished part passes through during
electrostatic spraying. Prior to electrostatic spray
painting, the surface of the conductive coated part is
5 submerged in a 90° F ELPO plating bath for five
minutes. (ELPO is a trademark of PPG.) The paint then
passes through a high voltage spray head which charges
the paint droplets. The paint then adheres to the
grounded surface without significant over-spray. Both
10 laminate and injection molded parts were painted
according to the bake cycles dictated by the GM paint
line specifications. The grey surface prime was first
sprayed at a dry coat weight of 1.2 mils and baked at
250° F for 20 minutes. Then the blue metallic color
15 base coat was sprayed at a coat weight of 0.9 mils and
was exposed to a heat at 160° F for three minutes.
Then the activated clear coat was sprayed on at a coat
weight of 1.9 mils and was baked at 250° F for thirty-
nine minutes for the final cure. The result was a
20 Class "A" finish that was tested to GM 4350M exterior
paint specifications. The majority of the testing was
essentially complete including the most critical cycle
testing. The painted surface has passed each test
segment of the specification. The parts have passed
25 the Xenon Arc SAE J1960 specification. Test results
are summarized as follows:

30

35

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	<u>Test</u>	<u>Index #</u>	<u>Description</u>	<u>Method</u>	<u>Results</u>
1	A	4.2.1	Initial Adhesion 610 tape	GM9071P	99+%
	B	4.2.9	Knife Crosshatch 610 tape	GM9502P	B(Pass)
5	C	4.2.2	Humidity Resist. & Adh. 610 tape	GM4465P 96 hours	Pass 99+%
	D	4.2.5	Chip Resist. min. rating of 7	GM9508P	GM 9
	E	4.2.7	Dime Scrape	GM9506P	Good Adhesion
10	F	4.2.6	Thumbnail Hardness no marring or paint removal	GM9507P	Not Marred
	G	4.2.8	Cure Test	GM9509P	Rating "0"
	H	4.2.11	Gasoline Puddle	GM9500P	Pass
	I	4.2.12	Gasoline Dip	GM9501P	Pass
15	J	4.2.10	Mandrel Bend rating of 0	GM9503P	N/A
	K	4.3.7	Abrasion Resist. CS10 wheels	GM9515P	N/A
	L	4.3.4	Cold Crack/ Corrosion Cycle 15 cycles/method A	GM9505P	(No effect) Pass
20	M	4.3.5	Color Crock ten complete turns	GM9033P	U/T
	N	4.3.6	Oven Aging	GM9504P	Pass
	O	4.3.10	Pencil Hardness Test	ASTM D3363	Gouge-H Scratch-B
25	P	4.3.11	Oil Immersion	Para. 4.3.11	Pass
	Q	4.3.2	Weatherometer Exposure - Xenon arc 1,000 hours	SAE J1960	None
30	R	4.3.1	Florida Exposure 2 years 5° facing south	GM4350M	U/T

Example 10

Referring to FIG. 10, a 0.8 mil thick conductive coating 22 described in Example 1 was coated on a matte release liner 20 also described in Example 1. The matte release film was laminated to 48 inch wide Lexan,

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1 Ultem, and Xenoy sheets. The rolls of laminate shown
 at 108 were extrusion cap sheet laminated and vacuum
 formed. Each conductive laminate roll 110 was mounted
 on an extruder 112. The Xenoy sheet can either be a
 5 monolayer extrusion or a 3-5 layer coextrusion with one
 or more of the layers being filled. The total layer
 thickness can be between 10 and 200 mils thickness. In
 this trial, a tri-layer extrusion 114 was formed 150
 10 mils in thickness through a 48" wide die lip. Such a
 tri-layer extrusion is shown in the embodiment of FIG.
 2 in which the extruded layers can be unfilled Xenoy
 28a, glass-filled Xenoy 28b and unfilled Xenoy 28c.
 Referring again to FIG. 10, the conductive laminate was
 15 fused to the surface of the extrudate 114 with the heat
 of the extrudate and the pressure at the nip of the
 metal rollers 116 and 118. The result was a 170 mil
 thick conductive sheet 120 ready for vacuum pressure
 forming into a finished electrostatic sprayable part.
 The following composites were successfully extrusion
 20 laminated and vacuum pressure formed:

	<u>A</u>	<u>B</u>	<u>C</u>
	Cond. Coat	Cond. Coat	Cond. Coat
	20 mil Ultem	20 mil Xenoy	20 mil Lexan
25	150 mil Xenoy Extrusion	150 mil Xenoy Extrusion	150 mil Xenoy Extrusion

 On a smaller scale, the conductive coating as
 described in Example 1 was coated on a matte release
 liner described in Example 1 and laminated to a 150 mil
 30 Xenoy coextrusion, resulting in the following
 construction:

	<u>D</u>
35	Conductive Coating
	25 mil Xenoy
	100 mil glass filled Xenoy
	25 mil Xenoy

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1 Each thick conductive sheet was then vacuum
pressure formed on a small scale die resulting in a
contoured conductive finished part that was
electrostatically sprayed as described in Example 9.
5 The conductive primer elongated during forming
substantially without affecting surface conductivity
which was sufficiently within the electrostatic
sprayable range. The painted part has passed GM 4350M
testing to date. Outdoor weatherability testing is in
10 process, with initial test results showing that the
spray painted parts have passed 1000 hour xenon arc
tests.

Example 11

15 Resistivity measurements (in K-ohms/sq.) were made
on both a commercial PPG conductive spray-primed fender
and a conductive thermoformed laminate fender of the
same shape made by the process of this invention as
described in Example 10. The conductive coating tested
20 was prepared from the formulation of Example 1. Forty
measurements were recorded randomly on the surface of
each fender. The following table demonstrates
significant statistical improvements in consistency
(uniformity of the conductive surface) with the
25 conductive primer (C. Coat) of this invention.

<u>Sample</u>	<u>Mean</u>	<u>Std. Dev.</u>	<u>6*St. Dev.</u>
PPG	56.6	30.2	181.2
C. Coat	1.1	0.22	1.32

30 Example 12

The following table shows conductive coatings that
have been successfully made in alternate resin systems
along with corresponding resistivity measurements
expressed in Ransberg units. In each resin
35 formulation, Vulcan XC-72 carbon black at a pigment-to-

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1 resin ratio of 0.23 was added and milled for three hours with 1/8 inch shot:

	<u>Resin</u>	<u>Source</u>	<u>Product No.</u>	<u>Ransberg</u>	<u>E.S. Sprayable</u>
5	Polyarylate	Hoechst Celanese	DKX-103	165+	Yes
	Acrylic	Rohm Haas	B-99	165+	Yes
	Polyether-imide	G.E.	Ultem 1000	165+	Yes
10	Urethane	Ruco	Rucothane Co-A-5002L	165+	Yes

No antiblock TS100 fumed silica was used. Each 0.8 mil coating was applied to the matte release liner as described in Example 1 and resistivity was measured directly on the web.

Example 13

A conductive coating described in Example 1 was applied to a matte release liner described in Example 1 and was laminated to a 20 mil thick polyarylate backing sheet. The polyarylate was the DKX-103 material used in Example 12. The polyester carrier remained on the surface during sheet molding trials (SMC) for protection. This laminate is only used for flat sheet SMC applications such as wallboard decorative panels. Compression molding on this structure resulted in a Ransberg resistivity measurement of 165+ units which is electrostatically sprayable.

Example 14

A conductive polyarylate film was cast on a two mil thick polyester carrier. The polyarylate film was made using DKX-57 (Hoechst Celanese) having a T_g of about 190°C. The polyarylate conductive film then was laminated to a 20 mil thick polyarylate sheet.

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1 Adequate adhesion and release of the carrier were
achieved without the use of a matte release coat.
Conventional lamination was with a thermoplastic size
coat such as Du Pont's acrylic 68080 applied at a
5 thickness of 0.3 mils between the conductive
polyarylate film and the 20 mil polyarylate laminate to
produce the following structure:

10 2 Mil Polyester
 Conductive Polyarylate
 Du Pont 68080 Acrylic Size
 20 Mil Polyarylate

15 The laminate with and without the size coat was
vacuum formed into a shell of contoured three
dimensional shape. The shell was placed in an SMC mold
and compression molded. The shell also can be placed
in a TMC mold and plastic injected behind it, resulting
in a finished electrostatic sprayable part. That is,
the conductive primer coat was sufficiently flexible to
20 elongate during vacuum forming, while still retaining
its original level of resistivity; and such resistivity
was reasonably uniform across the surface area of the
formed parts. When a flat sheet is desired, either
laminate can be placed flat in the mold and compression
25 molded.

Example 15

30 A lightly cross-linked conductive coating was
formulated with 2.5 parts Desmodur N100, an isocyanate
made by Mobay, Inc., with 100 parts of the conductive
coating of Example 1. (The Adcote X80-125 is a
polyester resin with hydroxyl functionality and is
capable of being cross-linked with isocyanites,
melamimes, and other functional resins.) The coating
35 was cast on the standard matte release layer at 0.8
mils dry. Both cross-linked conductive coating and
standard conductive coating were laminated to a high

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1 temperature polyarylate plastic sheet. FIG. 11
illustrates the extrusion laminating system for high
temperature laminating the conductive primer film to
the extruded sheet. This system is used when
5 laminating to high temperature plastics, such as
polyarylates, using high temperature-resistant primer
films such as the lightly cross-linked film of this
example. Referring to FIG. 11, a continuous extruded
sheet 122 of polyarylate is extruded from the die
10 opening of an extruder 124. The high temperature
extrusion is first passed between an upper roller 126
and an intermediate level roller 128. The extruded
sheet had a thickness of 20 mils. Separately, a high
temperature resistant conductive primer film 130 of
15 this invention is fed toward the extruder from a roller
132. The primer film is carried on the matte release
coated carrier sheet. The primer film and the extruded
sheet are fed to the nip of the intermediate roller 128
and a rubber roller 134 where heat and pressure are
20 applied to soften the coatings and bond the primer film
to the extruded sheet. The temperature of the extruded
sheet leaving the die exit opening can be over 600° F,
and bonding at the nip of the rollers 128 and 134 can
be at temperatures in excess of 400° F. The conductive
25 primer coated laminate then undergoes a temperature
reduction as it passes around a lower roller 136.
After bonding the primer film to the extrusion, the
matte release coated carrier is removed, leaving a
finished composite sheet 138 comprising a high
30 temperature resistant conductive primer film on the
exposed face of the high temperature resistant plastic
sheet. Temperature resistance of the conductive
surfaces was measured by exposing the coatings to heat
at 275° F for one minute on a 6 lb. metal surface, with
35 the following results:

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1

Cross-linked -- no pickoff, smooth
Standard -- pickoff, rough.

5

10

15

The conductive laminate was then thermoformed into a contoured shape. Further tests were made with greater degrees of cross-linking the conductive coat resin. The Desmodur N100 isocyanate cross-linking resin was added in 6 parts and in 15 parts to two separate vessels each containing 100 parts of the conductive primer formulation of Example 1. The two resins were coated on a matte release carrier and laminated to a 20 mil polyarylate backing sheet which was then thermoformed into a contoured shape. The results were as follows:

20

<u>Sample</u>	<u>Release</u>	<u>Thermoform Shell</u>
2 pts/100	OK	OK
6 pts/100	OK	OK
15 pts/100	poor	N.A.

25

30

It was concluded that thermoplastic resins or resins with a small degree of cross-linking are suitable for use in the conductive coat because they can elongate without degrading surface conductivity during molding or thermoforming. Cross-linking of the polyester resin up to about 10 parts cross-linking resin per 100 parts polyester is believed to produce a sufficiently thermoplastic conductive coat to retain electrostatic sprayability.

35

Example 16

Four separate conductive primers were made by varying the pigment-to-binder ratio. In this example, the binder was Hypalon 827B, a chlorinated polyolefin from DuPont. The particulate conductive filler

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1 material was XC-72 carbon black. The formulations are listed below:

5		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
	Hypalon 827B CPO	100	100	100	100
	XC-72 Carbon Black	23.3	17.5	11.7	5.5
	Toluene Solvent	289	289	289	289

10 Each formulation was made by first dissolving the Hypalon 827B in the toluene solvent and then dispersing the XC-72 carbon black in the blend using 1/8-inch steel shot. Each of these solutions was then cast onto a matte polyester carrier sheet at four thicknesses:
15 0.75 mil, 0.35 mil, 0.2 mil, and 0.1 mil.

Each sheet was then laminated to a 20 mil thick TPO panel and the matte polyester carrier was then removed, leaving a conductive film laminated to the TPO panel. (The TPO panel is described in more detail in Example 17.) Each of these conductive panels was then vacuum thermoformed over a mold which gave various elongations over the surface.

20 The amount of elongation over the areas of the mold was determined by molding pieces of 20 mil TPO which had an eight line per inch grid pattern. Measurements were taken along the various surfaces of the mold to determine elongations.

25 The amount of elongation over the areas of the mold was determined by molding pieces of 20 mil TPO which had an eight line per inch grid pattern. Measurements were taken along the various surfaces of the mold to determine elongations.

30 Ransberg resistivity and resistivity in K-ohms/square were measured before thermoforming and at six points on the mold after thermoforming. The readings are shown in Table 1 and Table 2, respectively.

Results show very high resistance and no electrostatic sprayability at a pigment-to-binder ratio of 0.055 at any film thickness. At a pigment-to-binder ratio of 0.117, the 0.1 mil product was not sprayable,

35

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1 and the 0.2 mil product lost sprayability at the higher elongations.

At a pigment-to-binder ratio of 0.175, sprayability was achieved and maintained until the higher elongations of the 0.1 mil product. At a pigment-to-binder ratio of 0.23, sprayability was achieved and maintained throughout all of the samples and elongations.

The conclusion is that sprayability can be maintained through higher elongations by increasing conductive film thickness and/or the pigment-to-binder ratio. Good results are achieved at pigment-to-binder ratios above about 0.175 and at conductive film thicknesses greater than about 0.2 mil.

15

TABLE 1

(Resistivity in Ransberg Units)

Test A - Thickness: 0.75 mil

	<u>Pigment-to-Binder Ratios</u>				
	<u>% Elongation</u>	<u>0.23</u>	<u>0.175</u>	<u>0.117</u>	<u>0.058</u>
	.0	>165	>165	165	83
	12.5	>165	>165	150	83
25	37.5	>165	>165	160	83
	43.8	>165	>165	165	83
	62.5	>165	>165	153	81
	131	>165	>165	155	81
30	156	>165	>165	155	81

35

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1

Test B - Thickness: 0.35 milPigment-to-Binder Ratios

5	<u>% Elongation</u>	<u>0.23</u>	<u>0.175</u>	<u>0.117</u>	<u>0.058</u>
	.0	>165	>165	152	83
	12.5	>165	>165	152	83
	37.5	>165	>165	152	83
10	43.8	>165	>165	150	81
	62.5	>165	>165	151	81
	131	>165	>165	143	81
15	156	>165	>165	150	81

Test C - Thickness: 0.2 milPigment-to-Binder Ratios

20	<u>% Elongation</u>	<u>0.23</u>	<u>0.175</u>	<u>0.117</u>	<u>0.058</u>
	0	>165	165	143	83
	12.5	>165	165	143	83
	37.5	>165	165	139	83
25	43.8	>165	165	132	82
	62.5	>165	165	135	81
	131	>165	151	83	81
	156	>165	151	80	81
30					

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Test D - Thickness: 0.1 milPigment-to-Binder Ratios

5	<u>% Elongation</u>	<u>0.23</u>	<u>0.175</u>	<u>0.117</u>	<u>0.058</u>
	0	165	149	83	83
	12.5	165	155	83	83
	37.5	165	145	83	83
10	43.8	165	140	81	82
	62.5	165	145	80	81
	131	147	85	80	81
15	156	139	80	80	81

TABLE 2

(Resistivity in K-Ohms/Sq. Units)Test A - Thickness: 0.75 mil

20	<u>% Elongation</u>	<u>0.23</u>	<u>0.175</u>	<u>0.117</u>	<u>0.058</u>
	0	.5	11	500	>500
	12.5	.4	6	>500	>500
25	37.5	.45	10	>500	>500
	43.8	.9	9	400	>500
	62.5	.6	11	>500	>500
30	131	1.4	10	>500	>500
	156	1.2	23	300	>500

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1

Test B - Thickness: 0.35 milPigment-to-Binder Ratios

	<u>% Elongation</u>	<u>0.23</u>	<u>0.175</u>	<u>0.117</u>	<u>0.058</u>
5	0	1.8	8	>500	>500
	12.5	1	30	>500	>500
	37.5	1.3	29	>500	>500
10	43.8	2.5	90	>500	>500
	62.5	2	55	>500	>500
	131	6	76	>500	>500
15	156	12	55	>500	>500

Test C - Thickness: 0.2 milPigment-to-Binder Ratios

	<u>% Elongation</u>	<u>0.23</u>	<u>0.175</u>	<u>0.117</u>	<u>0.058</u>
20	.0	11.5	200	>500	>500
	12.5	12	90	>500	>500
	37.5	25	110	>500	>500
25	43.8	36	300	>500	>500
	62.5	28	180	>500	>500
	131	70	400	>500	>500
30	156	80	500	>500	>500

35

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1 Test D - Thickness: 0.1 mil

Pigment-to-Binder Ratio

	<u>% Elongation</u>	<u>0.23</u>	<u>0.175</u>	<u>0.117</u>	<u>0.058</u>
5	0	50	>500	>500	>500
	12.5	90	>500	>500	>500
	37.5	190	>500	>500	>500
	43.8	160	>500	>500	>500
10	62.5	250	>500	>500	>500
	131	500	>500	>500	>500
	156	500	>500	>500	>500

15

Example 17

In this example the process was modified to test adherence of the conductive coat to a TPO panel. The TPO consisted of ethylene propylene rubber dispersed within polypropylene. The conductive coating in the polyester resin system from Example 1 was used to make the TPO sheet conductive by use of an understamp made by first casting a tie coat of DuPont's acrylic 68080 onto a silicone coated release liner from Hoechst Diafoil. The acrylic tie coat was applied at a dry film thickness of 0.3 mil. A water-based clear coat of a chlorinated polyolefin (CPO) from Aline, Al-112, was cast on the tie coat and dried to a film thickness of 0.3 mil. This construction was laminated to a 20 mil thick panel of the TPO. The conductive laminate from Example 1 was then laminated to this construction to produce the following construction:

0.8 mil conductive polyester
 0.3 mil acrylic tie coat
 0.3 mil chlorinated polyolefin
 20 mil TPO

35

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1 This laminate was then vacuum formed over the mold of
 Example 16 and resistivity measurements were taken in
 Ransberg units and K-ohms/sq. as follows:

	<u>% Elongation</u>	<u>Ransberg</u>	<u>K-ohms/sq.</u>
5	0	>165	0.11
	12.5	>165	0.11
	37.5	>165	0.11
10	43.5	>165	0.11
	62.5	>165	0.20
	131	>165	0.18
	156	>165	0.20

15

The conclusion is that good adhesion of the
 conductive film can be achieved for a TPO panel when
 the tie coat is cast separately as an understamp,
 rather than casting it directly on the conductive coat,
 and by use of the CPO to enhance adhesion. Casting the
 tie coat separately, followed by laminating avoids
 solvent attack of the conductive coat which may occur
 if the tie coat is cast directly onto the conductive
 coat. The result is that the conductive coat retains
 good resistivity levels through a wide range of
 elongations that simulate three dimensional shaping of
 the finished panel.

20

25

Example 18

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35

An acrylic-imide copolymer from Rohm & Haas was
 used in this example to manufacture a conductive
 laminate which can be used in an SMC process. The
 acrylic was HT-510, an amorphous acrylic-imide
 copolymer having a T_g (glass transition temperature) of
 149°C. (The glass transition temperature of a plastic
 is the temperature at which the plastic transitions

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1 from a brittle to a rubbery state.) Most acrylics have
a T_g of 105°C or lower. The SMC process uses mold
temperatures greater than about 135°C. This processing
5 acrylics. The conductive film made using the HT-510
acrylic-imide appears to survive the SMC process.

The HT-510 was dissolved in methyl ethyl ketone
and the XC-72 carbon black using 1/8 shot, with the
following formula:

10

<u>Ingredient</u>	<u>Parts</u>
Methyl Ethyl Ketone	300
HT-510 Acrylic-imide	100
XC-72 Carbon Black	23.3

15

This conductive primer was then coated onto a
matte polyester carrier and dried to a dry film
thickness of 0.6 mil. An adhesive tie coat of Irostatic
160/38 from Iromer Chemie was dissolved in methyl ethyl
ketone, with the following formula:

20

<u>Ingredient</u>	<u>Parts</u>
Methyl Ethyl Ketone	300
Irostatic 160/38	100

25

The tie coat was then coated onto the conductive
laminate to a dry film thickness of 0.1 mil. This
construction was heat laminated to a 20 mil thick
polyarylate sheet to produce the following
construction:

30

0.6 Mil Conductive Acrylic-imide Coat
0.1 Mil Irostatic 160/38 Size Coat
20 Mil Polyarylate Sheet

35

Resistivity readings taken in both Ransberg and K-
ohms/sq. measured greater than 165 Ransberg units, and
1.0 K-ohms/sq.

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1 This example shows a conductive film can be used
in an SMC process and maintained in a coherent state at
the higher SMC processing temperatures (above about
149°C). For material used in an SMC bonding process,
5 it is preferred to use a conductive film and a backing
sheet with a T_g of at least about 145°C, and more
preferably, a T_g greater than the temperature of the
sheet molding process.

10 The polyarylate backing sheet described herein is
one example of a suitable backing sheet; other
polyarylate backing sheets which can be used are
similar to those described in U.S. Patent Nos.
4,959,189 and 5,001,000, incorporated herein by
reference.

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1 What is Claimed is:

1. A process for making an electrostatic spray painted plastic panel, comprising the steps of:

5 coating an electrically conductive thermoplastic resinous primer coat on a heat-resistant carrier sheet and drying the primer coat to a uniform film thickness on the carrier sheet;

10 transferring the conductive primer coat from the carrier sheet and bonding the conductive primer coat to a thin, flexible, thermoformable plastic sheet;

15 forming the conductive primer coated sheet into a three-dimensionally shaped contoured substrate panel, in which the conductive primer coat is on the exterior surface of the contoured substrate panel and provides a substantially uniform surface resistivity level to the contoured substrate panel; and

20 applying a finished paint coat to the surface of the conductive primer coat on the contoured substrate panel, in which the finished paint coat is applied by electrostatic spray techniques.

25 2. The process according to claim 1 in which the carrier sheet has a release coat which comprises a matte release coat containing dispersed filler particles for transferring a micro-roughness to the surface of the conductive primer coat when the primer coat is transferred from the release-coated carrier sheet.

30

3. The process according to claim 1 in which the surface resistivity of the conductive primer coat has a Ransberg resistivity measurement greater than about 110 units.

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1 4. The process according to claim 1 in which the
 conductive primer coat comprises a polymer resin having
 a uniformly dispersed particulate conductive filler,
 the resin being selected from the group consisting of
5 polyester, acrylic, polyarylate, urethane and
 polyetherimide resins.

 5. The process according to claim 4 in which the
 conductive filler comprises carbon black.

10 6. The process according to claim 1 in which the
 plastic sheet is a thin, thermoformed face sheet, and
 further including bonding a molded substrate to the
 face sheet to form the finished panel.

15 7. The process according to claim 1 including
 extruding the plastic sheet and bonding a plastic
 substrate to the extruded sheet, followed by
 thermoforming the composite sheet and substrate.

20 8. The process according to claim 1 including
 extruding the plastic sheet, followed by laminating the
 conductive primer to the extruded sheet, using the heat
 of extrusion to transfer the conductive primer from the
25 release-coated carrier and bond the primer to the
 extruded sheet.

 9. The process according to claim 1 including
 electrostatically spray painting the conductive primer
30 coated face sheet to form a Class "A" exterior
 automotive paint coat on the surface of the contoured
 substrate panel.

 10. The process according to claim 1 in which the
35 conductive primer coat comprises a thermoplastic or
 lightly cross-linked thermoset resin.

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1 11. The process according to claim 1 in which the
conductive primer coat comprises a thermoset resin
having a high temperature resistance, and in which the
plastic sheet to which it is bonded is a thermoset
5 molding material.

12. The process according to claim 1 in which the
conductive primer has a reflectivity greater than about
70% to provide an EMI/RF shielded panel.

10

13. The process according to claim 2 in which the
release-coated carrier comprises a polyester carrier
sheet with a thermosetting resinous release coat
permanently bonded to the carrier film.

15

14. The process according to claim 13 in which
the release coat includes a silicon wax release agent.

15. The process according to claim 3 including
20 electrostatically spraying a finished Class "A"
exterior automotive paint coat on the primer coat of
the contoured substrate panel.

16. The process according to claim 15, in which
25 the finished paint coat is a weatherable thermoset
lacquer.

17. The process according to claim 3 in which the
carrier sheet has a release coat which comprises a
30 matte release coat containing dispersed filler
particles for transferring a micro-roughness to the
surface of the conductive primer coat when the primer
coat is transferred from the release-coated carrier
sheet.

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1 18. The process according to claim 17 including
electrostatically spraying a finished Class "A"
exterior automotive paint coat on the conductive primer
coat of the contoured substrate panel.

5 19. The process according to claim 18 in which
the finished paint coat is a weatherable thermoset
lacquer.

10 20. The process according to claim 19 in which
the conductive primer coat comprises a polymer resin
having a uniformly dispersed particulate conductive
filler comprising carbon black particles.

15 21. A process for making an electrostatic spray
painted plastic car body panel, comprising the steps
of:

 coating an electrically conductive
thermoplastic resinous primer coat on a heat-resistant
20 carrier sheet and drying the primer coat to a uniform
film thickness on the carrier sheet;

 transferring the conductive primer coat from
the carrier sheet and bonding the conductive primer
coat to a thin, flexible, thermoformable plastic sheet;

25 forming the conductive primer coated sheet
into a three-dimensionally shaped contoured substrate
panel, in which the conductive primer coat is on the
exterior surface of the contoured substrate panel and
provides a substantially uniform surface resistivity
30 level to the contoured substrate panel, said
resistivity level comprising a Ransberg resistivity
measurement greater than about 110 units; and

 electrostatically spray painting the surface
of the conductive primer coat on the contoured
35 substrate panel with a weatherable thermoset lacquer
paint coat to form an exterior automotive quality paint

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1 coat on the surface of the contoured plastic substrate
panel.

22. The process according to claim 21 in which
5 the carrier sheet has a release coat which comprises a
matte release coat containing dispersed filler
particles for transferring a micro-roughness to the
surface of the conductive primer coat when the primer
coat is transferred from the release-coated carrier
10 sheet to the thermoformable plastic sheet.

23. The process according to claim 21 in which
the exterior paint coat has a Class "A" automotive
finish.

15

24. The process according to claim 21 in which
the conductive primer coat comprises a thermoplastic or
lightly cross-linked thermoset resin.

20 25. In a process for making an electrostatically
spray painted plastic panel, in which a finished paint
coat is applied to the exterior surface of a contoured
plastic panel by electrostatic spray techniques, the
improvement comprising:

25 coating an electrically conductive
thermoplastic resinous primer coat on a heat-resistant
carrier sheet and drying the primer coat to a uniform
film thickness on the carrier sheet;

transferring the conductive primer coat from
30 the carrier sheet and bonding the conductive primer
coat to a thin, flexible, thermoformable plastic sheet;
and

forming the conductive primer coated sheet
into a three-dimensionally shaped contoured substrate
35 panel, in which the conductive primer coat is on the
exterior surface of the contoured substrate panel and
provides a substantially uniform surface resistivity

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1 level sufficient to bond the electrostatically sprayed
paint coat to the surface of the contoured substrate
panel.

5 26. In a process for making an electrostatically
spray painted plastic car body panel, in which a
weatherable thermoset lacquer exterior automotive
quality paint coat is applied to the exterior surface
of a contoured plastic car body panel by electrostatic
10 spray techniques, the improvement comprising:

coating an electrically conductive
thermoplastic resinous primer coat on a heat-resistant
carrier sheet and drying the primer coat to a uniform
film thickness on the carrier sheet;

15 transferring the conductive primer coat from
the carrier sheet and bonding the conductive primer
coat to a thin, flexible, thermoformable plastic sheet;
and

forming the conductive primer coated sheet
20 into a three-dimensionally shaped contoured substrate
panel, in which the conductive primer coat is on the
exterior surface of the contoured substrate panel and
provides a substantially uniform surface resistivity
level to the surface of the contoured substrate panel,
25 said resistivity level comprising a Ransberg
resistivity measurement of greater than about 110
units, sufficient for bonding the electrostatically
sprayed paint coat to the surface of the contoured
substrate panel.

30

27. The process according to claim 1 in which the
conductive primer coat has a pigment-to-binder ratio
greater than about 0.175.

35

28. The process according to claim 1 in which the
conductive primer coat has a film thickness greater
than about 0.2 mil.

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1

29. The process according to claim 1 in which the thermoformable plastic sheet is a thermoplastic polyolefin (TPO); in which the conductive primer coat is formed on a removable carrier sheet; in which a
5 chlorinated polyolefin (CPO) coat is formed on the TPO sheet, and an adhesive tie coat is formed on the CPO coat; and the conductive primer coat is then transferred to the tie coat side of the TPO sheet by
10 laminating techniques, leaving the conductive coat on an exterior face of the TPO sheet.

15

30. The process according to claim 1 in which the conductive primer coat is bonded to the substrate by a sheet molding compound (SMC) technique carried out at
a temperature greater than about 135°C, and in which the conductive primer coat and the thermformable plastic sheet have a T_g greater than the SMC molding
temperature.

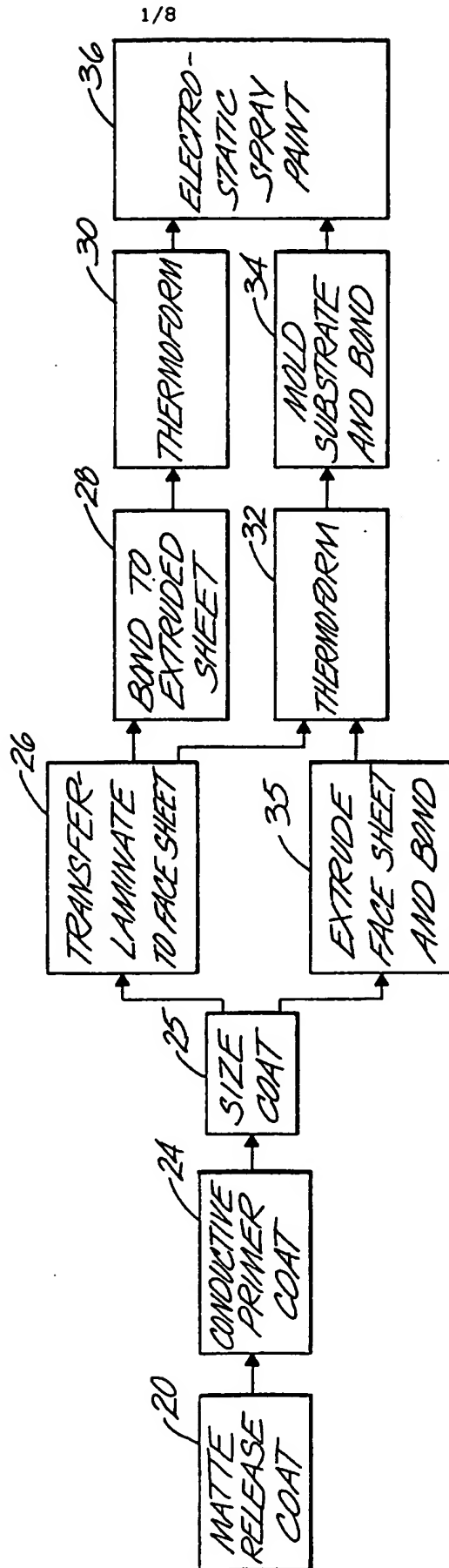
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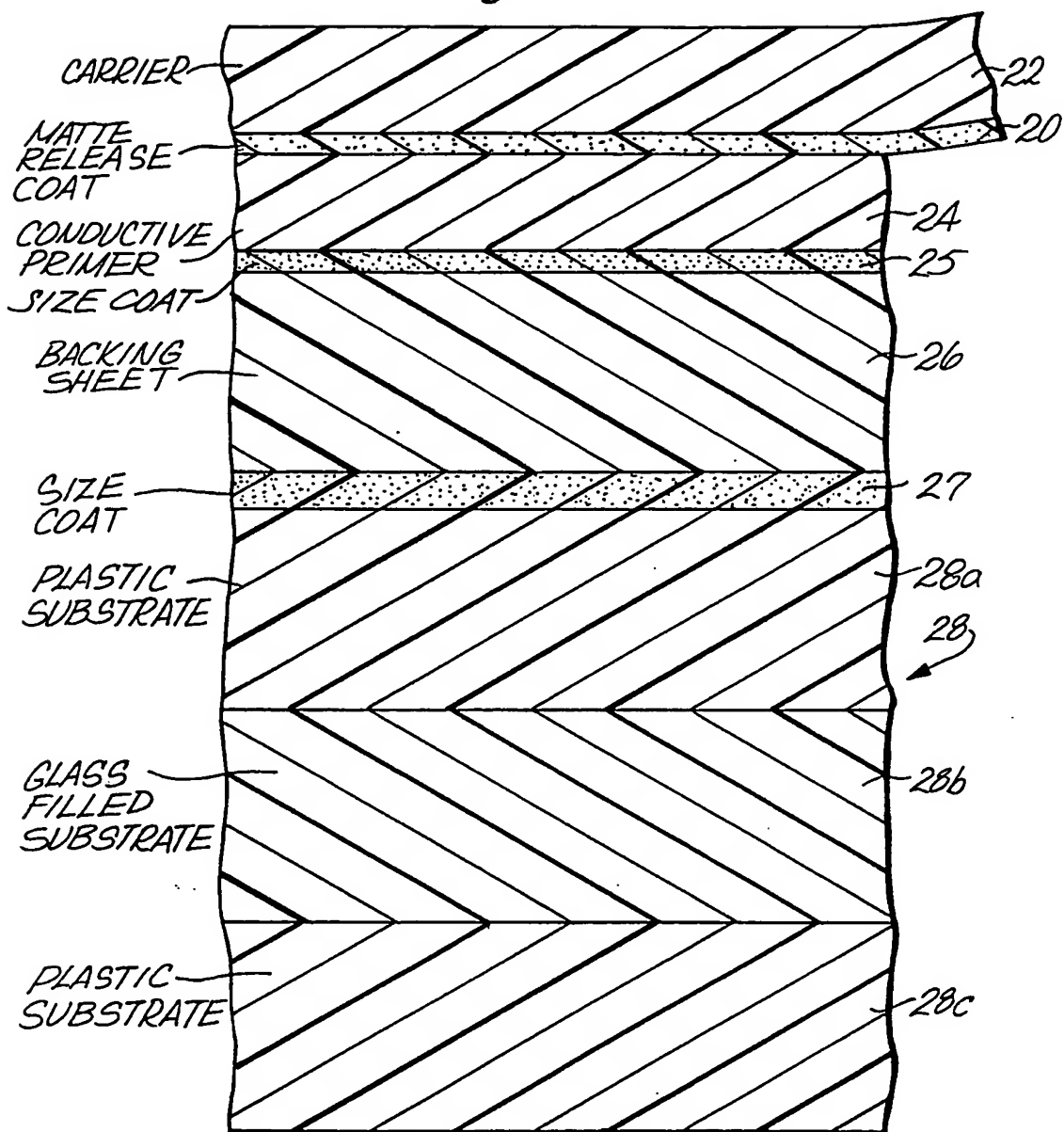
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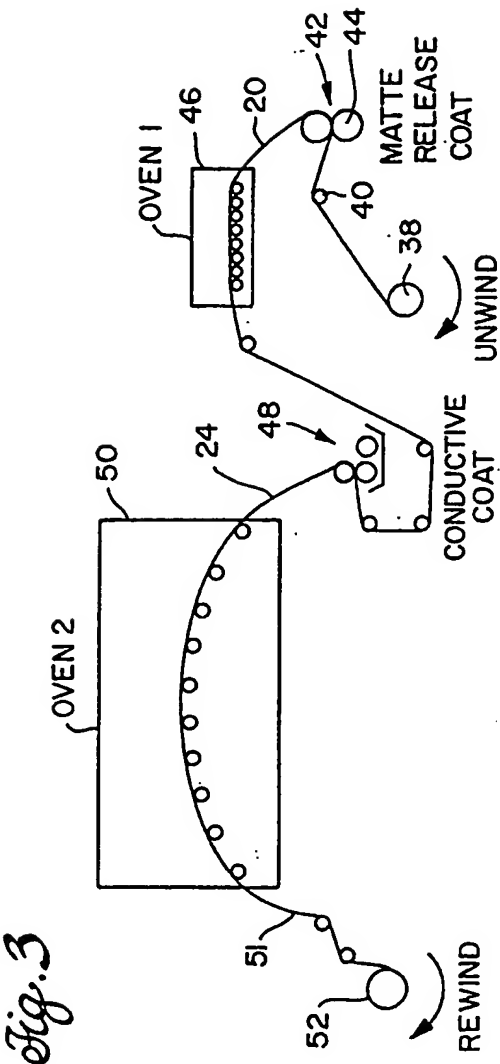
Fig. 1

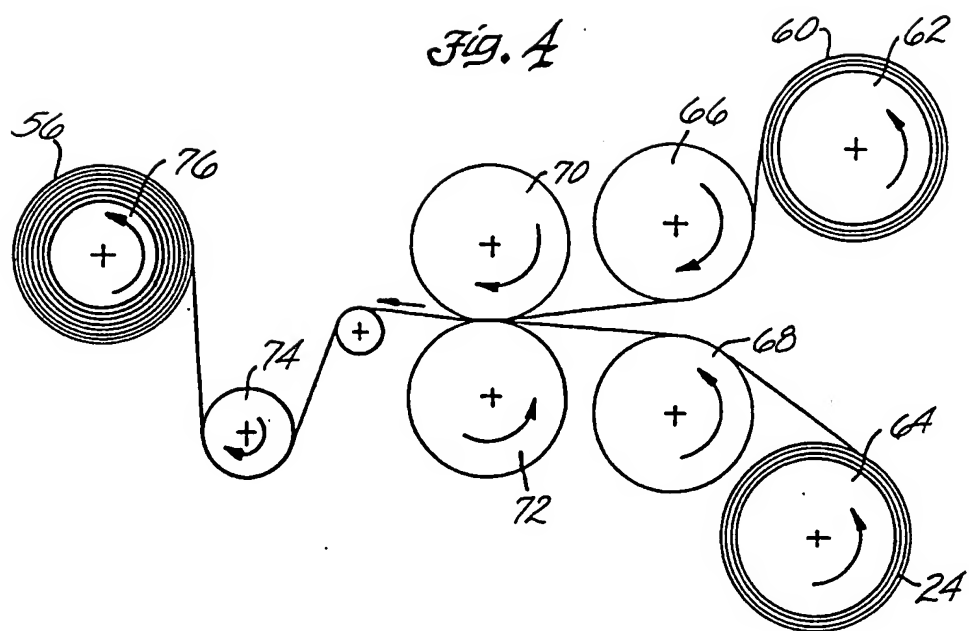


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Fig. 2







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Fig. 5

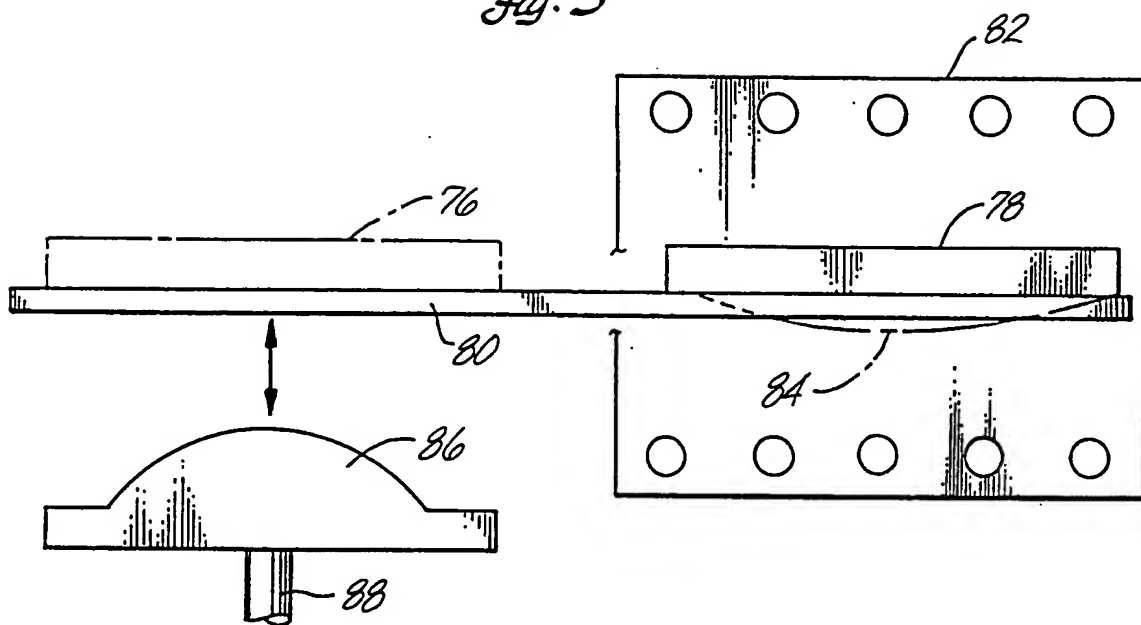


Fig. 6

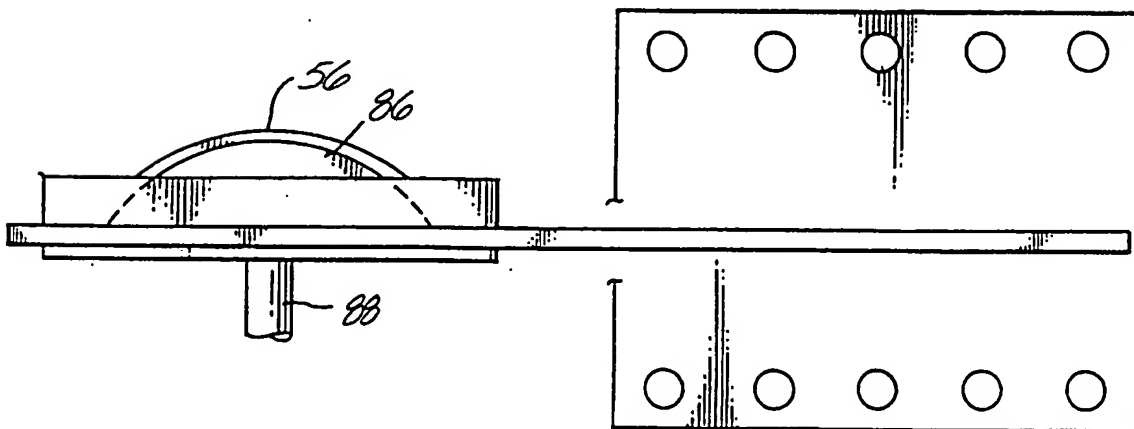


Fig. 7

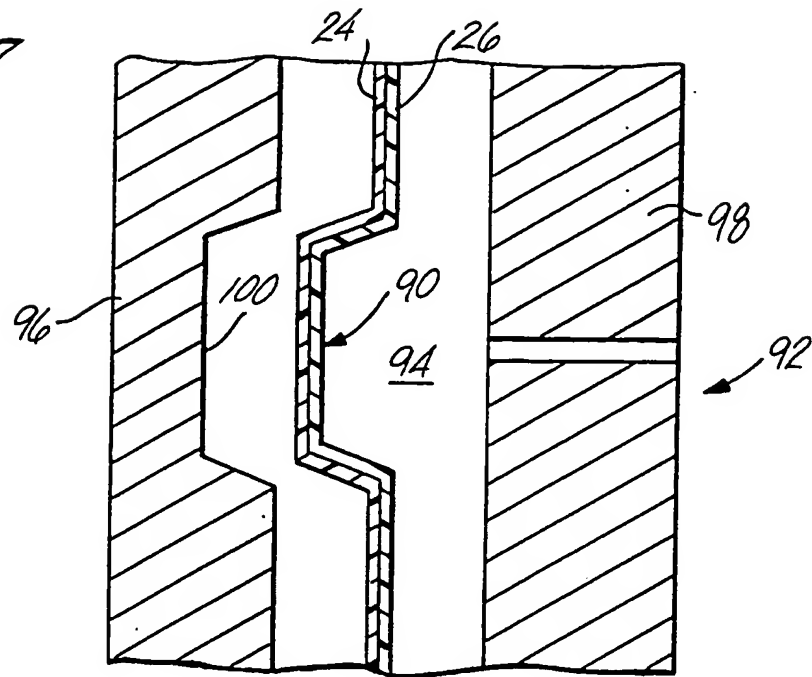
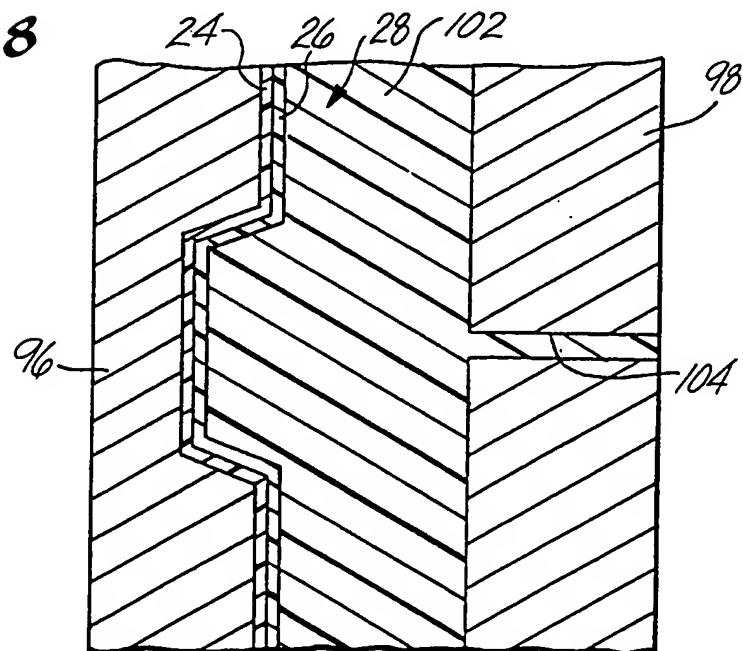


Fig. 8



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Fig. 9



Fig. 10

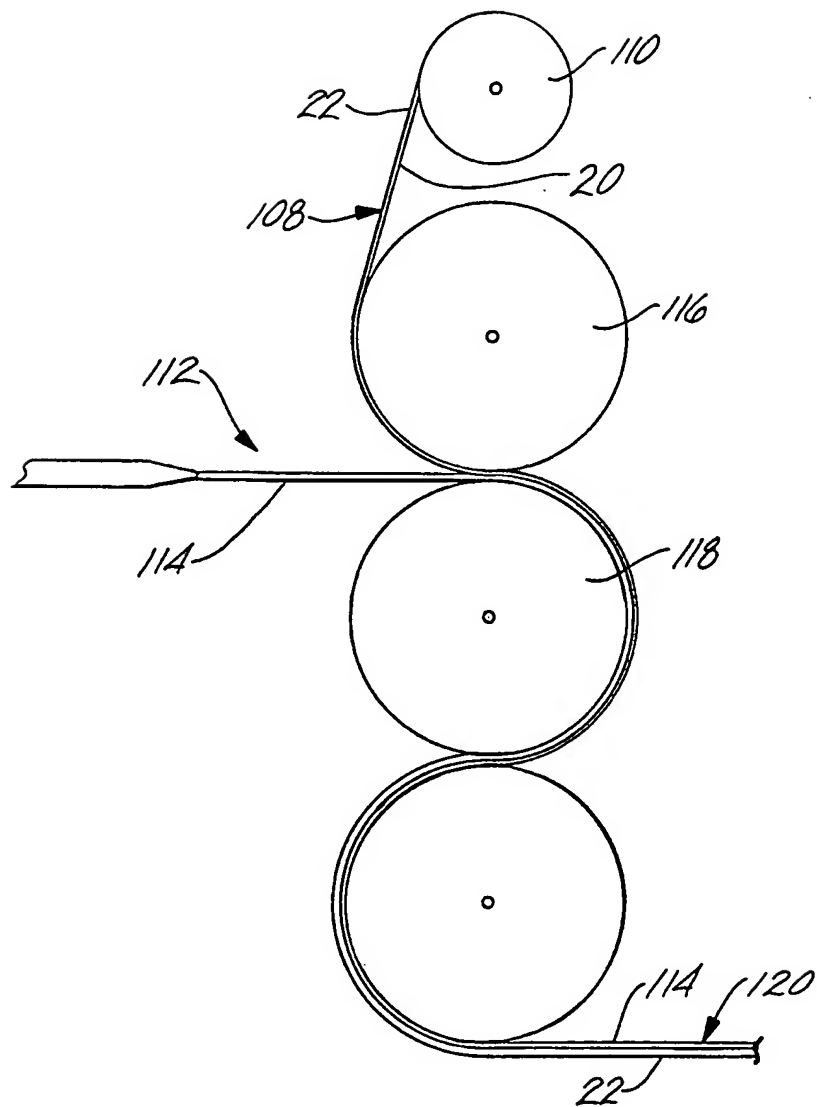


Fig. 11